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The Lime (Citrus) Tree Borer.

(*Chelidonium cinctum*, Guer.)

BY

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The early stages of this serious pest of lime and other citrus trees were first described very briefly by Mr. Anstead, now Director of Agriculture, Madras, in a note read before the 3rd Entomological Conference held at Pusa in February 1919. Certain important details pointing to a very simple remedy were, however, not observed by him. An account of these may not, therefore, be unwelcome to those who are interested in the cultivation of these valuable fruit trees. It was observed last year that the adult insect,—a metallic green beetle with a yellow cross bar on the wings,—emerges from the pupa late in the hot season towards the end of April or early in May. But on reaching the adult stage the insect does not immediately get out of the tree but remains there a good long while in the pupal chamber made by packing borings into partition walls before and behind the beetle in the tunnel it has made. Closely adjacent to each wall, there is a layer of chalk secreted evidently by the grub before it turned into a pupa. The beetle has a very fine smell, recalling that of lemon grass oil but not quite like it. Soon after the

first heavy showers of the monsoon are received, the beetle gets out of the tree. No adults have yet been detected in the lime groves, but late in June when eggs were looked for, they were found. At that time several twigs in each of the trees, smaller than a lead pencil in size, were observed withering and a little below these usually at a fork or at the origin of a spine, gummy exudations were noticed. When these latter were examined, the egg shells were found submerged in the gum or floating on the top of it. They were of a diaphanous green, broadly oval and with a rim all round and a delicate honey-comb pattern on the top surface. Where the eggs had failed to hatch, or their contents had been devoured by parasites there was no gum and they were found firmly fixed in the fork. The gum clearly, therefore, comes afterwards and as a result of the initial work of excavation of the young grub. The young grub eats a small oval patch of the bark just below the egg and then buries itself into the twig making a cork-screw cut round the twig, which, though it does not usually involve the bark, extends to the pith and is so complete that with a very light pull the twig can be broken off. After eating round the twig in this way the grub proceeds along the pith upwards towards the extremity of the twig.

As a result of the cork-screw cut gum exudes which submerges the empty egg-shell or lifts it off from its place. When the young grub hatches out plenty of rains have been received and there is a vigorous circulation of the sap for the growth of the fresh leaves noticed about this time. The larva in all its stages of growth requires plenty of ventilation and makes small holes along its track for the purpose. Unless therefore the circulation of the sap is cut off the air holes that it makes in the twig would soon get blocked up with gum and would not allow for proper respiration. It is therefore for this reason that the cork-screw cut is made by the grub. For much the same reason it is that the grub works its way upwards into the twig. For it is obvious, in a downward course, to cut off the sap first and then excavate is impossible.

How long the larva remains in the drying twig has yet to be determined but it is certainly at least a month. It appears likely that the return journey does not take place until the sap circulation becomes less vigorous. The course to the main part of the tree

also is marked by air holes through which the borings are discharged from time to time.

From the detailed description given above a simple remedy suggests itself. The cork-screw cut of the twig selected by the larva for its early excavations is so complete that a gentle knock or pull is all that is required to break it off and since the larva remains in the twig for at least a month the removal of the twig will secure the grub before it has had time to work its way back into the main part of the tree. The pruning of the drying twigs suggested in ignorance of the early habits of the grub is laborious and troublesome on account of the numerous spines of the tree. In the light of the habits now described such a procedure appears not to be necessary. The twig in which the larva works is easily noticed by its withering and the place of egg-laying by the exudation of gum which is fairly conspicuous. With a long stick ending in a narrow fork the dry twig can be easily removed. The twig is caught in the fork and a sharp turn is given to the stick in the hand when the twig is broken off and drops to the ground. No further action is necessary. The twigs may be left on the ground and the grubs having but very feebly developed legs cannot make their way again into the tree. This operation has been tested and found to be very easy, and there is at least a clear month after the twig has begun to dry in which to carry it out.

Sugarcane in Mysore.

PART I

BY

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History :—Sugarcane is an important industrial crop of Mysore and it is in cultivation from remote ages. It was chiefly confined to small areas under big tanks where there was a sure and an unfailing supply of water throughout the year. The area under cultivation and its importance fluctuated with the rise and fall of kingdoms and empires, for the security of life and property and the agricultural development greatly depended upon the stability of the governments.

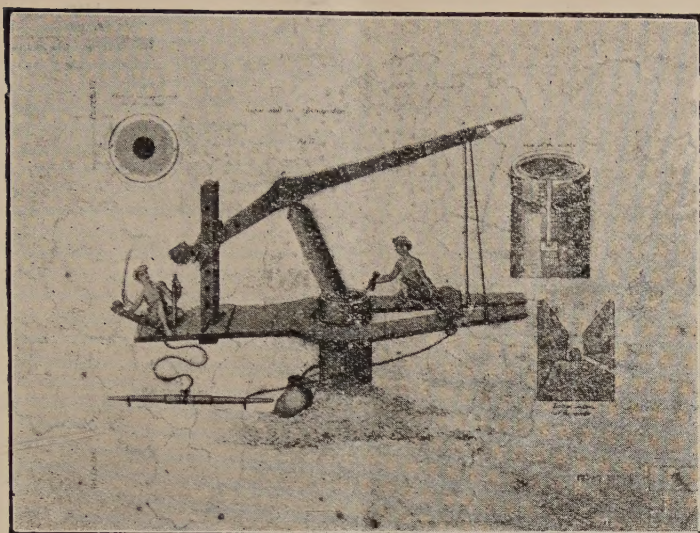
Sugar industry received a very great stimulus during the days of Hyder Ali and Tippu Sultan. To meet the expenses of their costly wars they tried to develop the resources of the country in every possible way. It was their aim to start all industries at Ganjam—an industrial suburb of Srirangapatna and the proverb

Bara Bandar ಬಾರಾಬಂದರ್ Twelve seaports

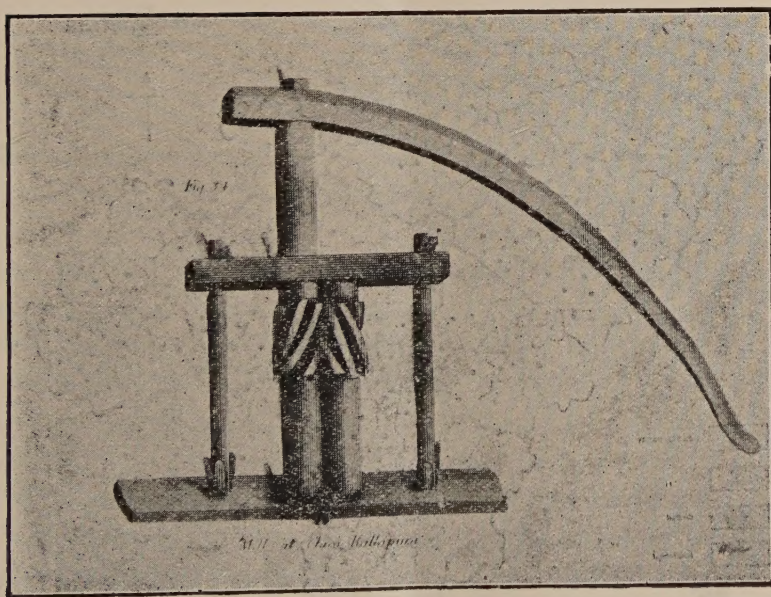
Ganjamka andar ಗಂಜಾಂಕ ಅಂದರ್ In Ganjam forts

is not unknown to many. At this time trained hands were imported from various places to start sugar refineries at Srirangapatna. During this period very large quantities of refined sugar were being imported from China. The cultivation of sugarcane itself was not extensive, the varieties grown were very poor and the methods adopted for milling cane and making jaggery were crude. A mill, very much like that of an oil-seed grinding mill, was used for expressing the juice in the southern part of the country from Chennapatna to Periyapatna. But in the northern part, conditions were better. Not only higher yields were obtained by better cultivation but also canes were milled in two-roller wooden mills worked by endless screws. The varieties of cane cultivated were poor reed-canes and the thick white Rasathali cane, but it was not possible to make any sugar from them as the syrup from their juice would not granulate. It was this difficulty in making sugar that led to the introduction of better types of canes into the country during the time of the Moslem rulers. An officer of rank—one Mustapha Alli Khan, Pay-Master General in Hyder's Government, introduced the Striped Sugarcane from Arcot. It became so popular that by the end of the 18th century it had spread almost all over the country within thirty years of its introduction and the older and poorer types of canes gradually began to disappear from cultivation. A few of them are now found as a mixture in the bulk crop in some localities. The striped cane is now the most important variety in the State. It has satisfied the ryot from the Malnad in the west to the dry taluks in the east. After the fall of Srirangapatna cane cultivation did not receive any special impetus. There were some spasmodic attempts to introduce new types of cane at various times. By 1880 the hard reed cane—Cheni—had come to stay in the State. A few trials with Mauritius Canes were made at Chickmagalur and though found to be very vigorous they did not become popular as their hardness stood in the

SUGARCANE IN MYSORE—PART I.

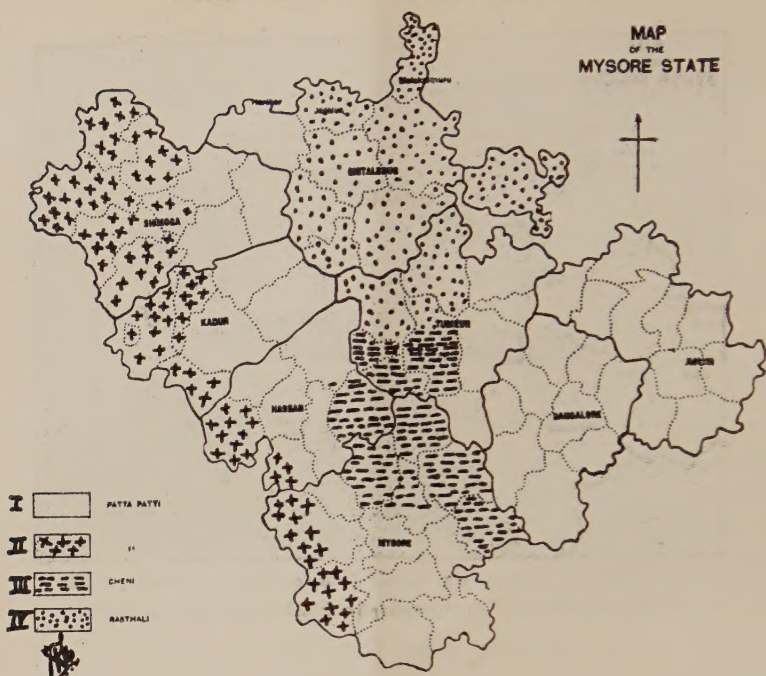


Sugarcane mill built on the model of the ordinary oil mortar mills in use in 1800 in Channapatna, the Southern part of the State.

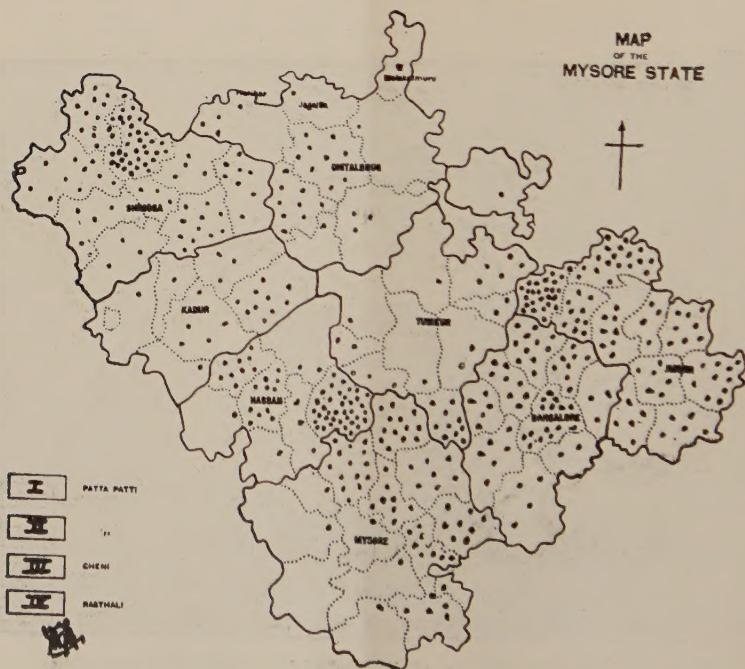


Two-roller wooden sugarcane mill worked by endless screws used in Chikballapur, Kolar District, in 1800.

SUGARCANE IN MYSORE—PART I.



Belts of Sugarcane in the State.



Every dot stands for 100 acres of sugarcane under cultivation.

way of milling with the country mill and small bullocks. Even after 1800 some attempt was made at Sidlaghatta and Doddaballapur to make white sugar, but the attempts failed as they could not compete with white sugar from China, which was sold at a cheaper rate in the market. In 1847, Messrs. Groves & Co. established a factory at Palhally, near Srirangapatna to prepare white sugar from the jaggery made by the ryots. It was started as the "Ashtagram Sugar Works" and later on it was converted into a joint stock company. The refined sugar turned out by the factory was a high grade one and it won gold medals at the Great Exhibitions of London in 1851 and 1861, and it also secured "Honourable Mention" at the "Universal Exhibition" in Paris in 1867. At one time in its heydays as many as 300 labourers and 10 Europeans were employed in the factory. But with the retirement of the agents and the change in the regulation of the supply of water in the channels the activities of the factory ceased. The magnitude of the working of the factory could be gauged by a study of the output from the factory. The following was the estimated value of sugar produced for five years :—

			Rs.
1881-2	..	..	8,44,175
1882-3	..	..	5,34,150
1883-4	..	..	13,88,918
1884-5	..	..	14,30,473
1885-6	..	..	18,73,554

Another sugar factory was set up at Goribidnur by Messrs. Arbuthnot & Co. This factory not only handled cane-jaggery, but also dealt with Palmyra jaggery from the South and imported it in large quantities when the price of cane-jaggery was very high. It opened a large cane plantation under the Marikanve project, but the whole concern came to an end with the winding up of the firm. Since then the property has changed hands many times.

A Sugarcane Plantation Company was started by a few local men at Shikaripur, but it worked only for a short time.

Very large quantities of soft raw sugar are now made in the State and exported. In 1917 about Rs. 13,05,068 worth of such raw sugar was sent out in addition to Rs. 10,26,503 worth of jaggery.

Many improvements have been effected in the industry since 1900 along with the general progress of the State. The old grinding mills have gone out of memory, the wooden roller mills are remembered

only by a few, and the three-roller iron mills have already replaced the two-roller ones almost everywhere, and power-mills, oil engines, and centrifugal pumps have made their appearance in a few large estates. Within the last fifteen years many problems have been tackled and solved, many varieties of cane introduced and tested, manurial problems have been investigated and many practical suggestions have been made to extend the industry and to improve it, and most of these suggestions have been translated into action with the co-operation of the people and the help of Government. Fresh problems are facing the industry and these are being investigated by the Agricultural Department and ere long the industry seems to have a fair chance to prosper and help in the economic advancement of the State.

Extent :—Since 1917, war conditions have affected every industry in the State and in many cases the fluctuations are quite abnormal. As the conditions were about normal in 1917, statistics for that year have been taken into consideration throughout. In the year 1917 there were about 36,141 acres of sugarcane under cultivation in Mysore, representing only 0.5 % of the total area cropped in the year, and 3.6 % of the total irrigated area in the State. In 1882 there were only 25,956 acres and this gradually rose to 47,430 acres in 1902, showing an increase of 82.7 %. But it fell down to 36,141 acres in 1917 with a reduction of 24 % of the area under cane since then. The immense possibility for extension might be seen from a comparison of the areas under sugarcane and paddy, where it is found that the proportion is 1 : 22.

Extent of cane cultivation in each District :—

District.	Net area cropped. acres.	Irrigated area. acres.	Area under Sugarcane. acres.	Per cent of Irrigated area.
Bangalore ..	7,05,079	68,853	5,124	9.4
Kolar ..	5,52,223	1,01,711	8,977	8.8
Tumkur ..	10,23,417	96,656	1,923	1.9
Mysore ..	13,72,624	1,31,152	4,950	1.9
Hassan ..	6,45,655	1,27,534	4,087	3.8
Shimoga ..	5,15,107	2,76,744	8,231	2.9
Kadur ..	4,42,400	1,27,113	1,738	1.3
Chitaldrug ..	12,06,165	76,787	1,111	1.4
Total ..	65,22,670	10,06,550	36,141	3.6

Large areas of sugarcane are found near Shikaripur, Chennarayapatna, Krishnarajpet and Goribidnur. Cultivation in every place is not of the same standard and the yields vary in every locality. The following table gives the probable standard outturn of jaggery per acre in each of the districts :—

Probable tonnage of cane.		
	Mds.	Tons.
Bangalore ..	140.6	16.0
Kolar ..	153.7	19.0
Tumkur ..	127.7	15.0
Mysore ..	137.3	17.0
Hassan ..	95.6	12.0
Shimoga ..	61.6	6.0
Kadur ..	67.8	6.0
Chitaldrug ..	43.3	5.0

Average for the State :—102.2 mds of jaggery (1 md.—960 Tolas or 24 lbs.) or 12.6 tons of cane per acre.

The estimated crop is about 66 per cent of the standard yields during every season.

The above figures give enough data to show how much improvement could be effected in cane cultivation in each district and as a whole in the State. The area could be extended easily and the outturn per acre may be greatly increased by four to six times in some parts.

Irrigation Facilities :—Broadly speaking, the cane area may be divided into different zones having the following irrigation facilities :

- (1) The rainy Malnad with heavy rains and swollen streams.
- (2) River channels in the plains.
- (3) Major tanks with an abundant supply of water.
- (4) Small tanks with a limited supply of water.
- (5) Wells.
- (6) Thalapariges or channels drawn off from sandy streams.

The uncertainty of rainfall and the precarious supply of water in minor tanks are also responsible for the fluctuation in the areas under cultivation every year though the ruling prices of jaggery at the time of planting greatly influence the planter to extend or restrict the area under cane. The largest areas are to be found under big

tanks, and Bangalore and Kolar being the regions of big tanks head the list with 14 and 25 per cent of the total area under cane.

Dividing the whole State into regions having different natural facilities for cane cultivation the following four groups are obtained :—

(1) The Malnad belt—Long narrow strip lying over the ghats and having a heavy rainfall ranging from 100 in. to 400 in.

(2) The valleys of the Thunga-Bhadra in the north, the Hemavathi, the Kaveri and the Kapila in the south. This area has an average rainfall of 35 in. and is well protected by river channels.

(3) The dry central belt with low rainfall and poor soils. In the north, in the black soil zone, very little sugarcane is grown, but in the southern part large areas are under hard reed canes grown with the help of small tanks and shallow wells. This is the region of saline soils.

(4) Bangalore and Nandi Tableland with valleys running off from it in all directions. This area contains the largest number of tanks and a number of them are very big ones. Nearly 42.2 per cent of the total cane area is found in this region.

Different zones and the extent of cane cultivation :—

	Total irrigated area, acres.	Total area under cane acres.	Per cent of irrigated area.	Per cent of cane area.
1. The Malnad Belt :—				
Mostly Pattapatti cane. Some Cheni also	3,77,720	7,417	1.9	19.9
2. River Valleys :—				
Mostly Pattapatti, Cheni to some extent	2,30,876	6,675	2.9	17.9
3. Central Dry Belt :—				
(a) In the north. Mostly Rasthali. Some Cheni	1,19,406	1,132	0.9	3.0
(b) In the south Mostly Cheni and some Pattapatti ..	59,473	6,241	10.4	16.0
4. Eastern Tableland :—				
Mostly Pattapatti and some Cheni in Kolar ..	2,13,675	15,682	7.3	42.2

Total production of jaggery for each belt :—

	Standard Yield. Mds.	Average Yield per acre. Mds.
Belt No. 1 ..	1,49,655	48
Belt No. 2 ..	12,59,658	121
Belt No. 3(a) ..	43,400	63
Belt No. 3(b) ..	5,56,874	85
Belt No. 4 ..	24,21,505	157

The above figures show the standard of cultivation in the eastern parts of the State and one can work out the increased production if the other parts also exert to adopt better methods of cultivation. Experiments have shown that it is possible to obtain easily 300 mds. of jaggery and even as much as 600 mds. by using artificial manures and new varieties of cane. As Mysore already exports large quantities of sugar products and gets money in return, we can expect to get more capital to flow into the country by sending out more sugar and thus secure more wealth for the general progress and reconstruction.

Varieties of Sugarcane :—The different varieties of Sugarcane grown in the State may be classified under the following heads :—

1. Stout Soft Canes.
2. Hard Reed Canes.
3. Exotic Canes.
4. Seedling Canes.

1. *Stout Soft Canes*.—(a) Rasthali.—This is a soft white cane and is supposed to be the original cane of Mysore. It ripens in about 10–12 months and deteriorates rapidly afterwards. It is generally planted in one season only during Chitra (April) and it does not ratoon well. It is a rich juicy cane but not so rich as Pattapatti in sucrose, and it contains more of glucose. It is a very good chewing cane. At present it is the dominant type in Belt 3(a) especially in Chitaldrug. To some extent it is found in Kolar and only as a mixture in other places. It is largely grown under wells. It has a thin rind, does not tiller freely, lodges very much, and is badly attacked by jackals and borers.

(b) Pattapatti or Striped Cane.—This was introduced into the State about 150 years ago, and has now become the main type in the

State. It is probably one of the richest canes in the world. Sometimes its juice has analysed as much as 22 per cent of sucrose. It tillers freely and responds well to good cultivation. It requires plenty of irrigation and is therefore found in large areas where plenty of water is available under major tanks and channels. It can be planted in two seasons—once in April—in Chitra and again at about the time of Gouri feast before the setting in of the N.-E. Monsoon. It is now the dominant type in Belts 1, 2 and 4. It produces a good coloured hard jaggery and fine sugar may be made from it. Being a top heavy cane, it lodges very much, matures in about 12 months, but does not deteriorate as rapidly as Rasthali does. It is a good chewing cane. It ratoons very well, and does not flower freely, but being a soft cane is attacked by jackals.

(c) Mullu Kabbu is a soft white cane with bristles on the leaf sheath.

Bile Kabbu is a soft white cane without bristles.

Neeli Kabbu and Kare Kabbu are purple coloured canes with hard rind.

The above canes are found as mixtures in bulk crops. These are only the remnants of canes which have gone out of cultivation.

2. *Hard-rinded Reed Canes*.—(a) Cheni.—This seems also to be an introduced cane, for no mention of it is made anywhere a hundred years ago. It seems to stand drought very well and thrive to a certain extent on alkaline soils. It is grown mostly under tanks having a small supply of water and supplemented by well irrigation. It gives a good yield under good cultivation, but owing to the low standard of cultivation the average yield of the crop is very poor. It is supposed to ripen in 18 months, but keeps longer if left on the field and even 30 months old crops are known to produce good jaggery. An average crop gives about 60–80 mds. of jaggery to the acre compared with 200–300 mds. from Pattapatti. The jaggery is light-coloured, hard and keeps for a long time, but it has a slight alkaline taste. There are many types of hard canes in the State which come under this group but this one is the dominant type and the others are only remnants of older types. The most important of them are :—

- (1) Gandu Cheni—(This is the real Cheni).
- (2) Hotte Cheni.
- (3) Putte Cheni.

The Cheni cane is the dominant type in Belt 3(b). It is a very free tillerer, but being a hard reed cane contains less juice than the soft canes. The juice is rich in sucrose and contains only a small quantity of glucose. It is subject to Smut and Leaf Spot diseases, but being a hard cane it is not attacked by wild animals.

(b) Mara Kabbu.—This is a hard reed cane which was grown in Kolar and Bangalore before the soft Pattapatti cane was introduced. It is now found to some extent in Belts 1 and 3 (a) and in Kolar.

(c) Hullu Kabbu and Katte Kabbu.—These are hard reed canes grown in the State long before the introduction of better types of canes and now they are found as a mixture in the bulk crop in rare cases.

3. *Exotic Canes*.—So far back as 1880 attempts were made to introduce Mauritius canes. Though they were found to be very vigorous, their cultivation did not extend, for their hardness made them unpopular. Since 1905 a large number of foreign canes have been imported and tested under local conditions. Many of them have been rejected as they did not suit our conditions here, though they are about the best canes in the countries from which they were introduced. In this way B 208, Ashy Mauritius, Striped Mauritius, White Mauritius, Java 247 and a host of other good canes have been rejected. Since 1914 a very large number of fresh canes have been procured through the courtesy of the various Agricultural Departments from the West India islands, Java and the Malay States. Some of them are promising but the free flowering of these canes so reduces the yield that there is no chance of most of them becoming popular. Some of them are now being tested on the various farms to observe their behaviour under different conditions.

Out of those exotic canes which have been already tested Java (Mysore) and Red Mauritius have gone into cultivation.

Java (Mysore).—This is getting popular in the semi-Malnad areas of Belur, Hassan and Kadur. It does not tiller freely and produce a heavy yield of jaggery. But being a light coloured cane produces a fine jaggery. In this area the local Pattapatti cane is supposed to ripen in 14 to 18 months and as this one ripens in 12 months and gives a good light-coloured hard jaggery it is becoming very popular in the heavy soils of the semi-Malnad. It flowers

and lodges to a great extent. The rind is hard and it is not attacked freely by jackals.

Red Mauritius.—A stout red cane, very vigorous in habit and produces very heavy yields. So far in our tests it has given the best results. It does equally well both in the Malnad and in the plains. In the Malnad, the second or ratoon crop seems to give a bigger yield than the plant cane. It is being largely distributed by the Department in all parts of the State. Sometimes it flowers freely in certain localities. It has a hard rind and contains much fibre and therefore does not lodge. It is not attacked by wild animals. It responds well to good cultivation and manuring. The drawbacks it has are many and they stand in the way of its general adoption. In some places it is considered too hard for milling and its red colour imparts a dark appearance to the jaggery and thus reduces the price in the market. Further it is not a very rich cane and contains a large percentage of glucose as a result of which the jaggery does not keep long. The Malnad ryot seems to have given up liming to preserve a good colour and prepares only liquid jaggery as before. But if the canes are required for a sugar factory where the colour is not a serious matter this cane is eminently suited for large plantations.

Chemical analyses of various canes :—

		Percentage of Sucrose in Juice.	Percentage of Glucose in Juice.	Colour of cane.
<i>Stout Canes :—</i>				
1. Local Striped	..	19.0	0.5	Red & Yellow.
2. Rasthali	..	16.4	1.2	Yellow.
3. Vellai	..	17.6	0.8	„
4. Red Mauritius	..	17.4	0.8	Red.
5. Striped „	..	17.0	0.6	Red & Yellow.
6. Ashy „	..	18.9	0.2	Red & Bloom.
7. Purple „	..	17.5	0.9	Purple.
8. White „	..	16.0	1.1	Yellow.
9. No. 65	..	14.6	1.1	Red.
10. No. 131	..	15.9	0.9	Red.
11. B. 208	..	20.4	0.2	Yellow.
12. Java—Mysore	..	18.3	0.7	„
13. „ 247	..	16.8	0.3	Brown.

	Percentage of Sucrose in Juice.	Percentage of Glucose in Juice.	Colour of cane.
14. Tanna Striped ..	18.1	0.5	Red & Yellow.
15. Tanna Blanche ..	18.3	0.5	Yellow.
16. White Transparent	18.7	0.2	"
17. Demarara 74 ..	18.2	0.5	"
18. B. 3412 ..	18.2	0.3	"
19. Elephant Cane ..	14.7	1.0	Yellow & Bloom.
<i>Reed Canes :—</i>			
20. Cheni ..	18.9	0.4	White & Bloom.
21. Java 33(a) ..	17.7	0.4	Red & Bloom.
22. „ 36 ..	18.7	0.2	"
23. „ 139 ..	19.9	0.07	"
24. Dhar ..	18.75	0.09	Yellow.
25. Nanal ..	18.7	0.1	"
26. Majorah ..	17.0	0.2	"
27. Hotte Cheni ..	17.0	0.1	"
28. Putli Khaji ..	17.0	0.5	"

4. *Seedling Canes.*—About 1912 it was found that sugarcane did produce fertile seeds in India. At Coimbatore a few seedlings were successfully raised. In 1913, a dozen seedlings were raised from Cheni cane for the first time in Mysore. The climatic conditions in Mysore, especially near Bangalore, seem to be well fitted for the fertilization of sugarcane flowers. Since 1913 many thousands of seedlings have been raised from various types of canes and a few thousands have been grown to maturity and tested. The seedlings vary in vigour, colour, period of maturity, richness of juice and in general habit. This range of variation allows one to make a large number of selections to meet the requirements of the different localities. In this work it was found that some canes were good as parents whose seedlings were always better than those of others. Seedlings have been raised from almost all the types of cane under observation. Many seedlings were raised from the local Pattapatti and it was found that a large number of them resemble the Cheni and other reed canes—Mullu Kabbu and Kare Kabbu. It may be that these are chance seedlings. It has been found that in January, if a cloudy and rainy week sets in, most of the arrows that have fallen down

germinate. This phenomenon has been observed for two seasons. At present there are about 600 good seedlings in the stud plots and most of them have been tested against the local striped cane and Red Mauritius to see if they would give better yields than these. A few of those that are promising are now being tested on different farms and private estates. Seedling canes like H. M. 544 (Hebbal Mauritius); H. M. 320; H. M. 553 and H. M. 312 are seedlings of Red Mauritius and they are yellow or light in colour, vigorous in growth, rich in sugar, and contain only a small quantity of glucose. In the preliminary trials they gave better results than the Red Mauritius. In most of the localities where they were tested they were very successful and have caught the liking of the people. All canes grown on the farms have been used for planting and at present they are being grown over a very large area in the State. In some places, 60 tons of cane to the acre have been harvested by growing them. It is therefore hoped that in this direction lies a way of obtaining the required kind of cane for the different parts of the State.

Lines of Improvement.—The present need of the country is for a vigorous, rich, light-coloured cane, which ripens in 12 months and does not easily succumb to insect and fungoid pests. As there are different localities having different ecological conditions, evidently one type of cane is not suited to all the places. Therefore canes having the above general qualities and suited to the following conditions are required :—

- (1) Canes to withstand heavy rains in the Malnad.
- (2) Canes for flat heavy soils.
- (3) Canes for heavy black soils.
- (4) Canes for light porous soils.
- (5) Canes for water-logged soils and soils with slight alkalinity.

The local Pattapatti cane does not flower as a rule but sometimes it does. Even then, the flowering is not general as in the case of foreign canes. In this place the flowering season seems to be between October and January. If the cane does not flower this is just the time for rapid growth and if it does flower the tonnage per acre is greatly reduced. Therefore the flowering habit is a great defect in any cane for our conditions here. Probably by changing the time of planting this flowering habit may be overcome but it is an intricate problem as it affects the yield, rotation, labour, price

in the market and water supply. Detailed investigation is required in this direction.

The average size of each holding is very small, being not more than half to one acre. Though two to three acres are often seen eight to ten acre plantations are rare and there are only a few people owning cane plantations of more than twenty acres in extent. Sometimes even in these small areas a number of people join together and grow cane.

Water is the limiting factor in the State. But Labour has become the limiting factor in the new areas opened up under big reservoirs. Want of capital is also a great obstacle. The cultivators want money for the purchase of mills, bullocks, and manure, and for paying extra labour. Sugarcane is an important industrial crop though large quantities of cotton, fruits, and cereals are exported. Other crops do not pay the ryot so much as sugarcane does and cane cultivation keeps the whole family employed, when there is no other work on the farm. At present there is no likelihood of any other crop taking the place of sugarcane; though mulberry is a serious rival the silkworm cannot be reared profitably everywhere. If there is no labour or the season is missed, paddy is substituted in its place. To some extent plantain has replaced cane on small areas near towns, but it is not a serious rival.

There is a great scope for further extension especially in the Malnad, under Marikanve and the big major tanks and in the canal areas. Climatic conditions in the Malnad are well suited for the growth of canes. The valleys are well watered and sheltered. If only a series of tanks are built to store water, the future big plantations may be transferred to this area. The storage tanks would not only help to irrigate during the hot dry months but also would give enough of water to generate power to crush the canes in the factory.

Deterioration of varieties of cane does not seem to take place so soon as is believed in some quarters. Some people believe in it and exchange their seeds with their neighbours or their adjoining villages. Comparing the yields of Pattapatti of the present time with those of a hundred years ago the cane does not seem to have deteriorated at all. It may be that when a cane is newly introduced, being grown on a small area, it is grown with great care and heavy yields are obtained. When the same variety is grown on larger

areas under different conditions and with less care it naturally begins to give a smaller yield and this result should not be taken as a sign of deterioration ; or if the cane is not suited to the locality it may not thrive at all and may get extinct in course of time if it is further subjected to insect pests or fungoid diseases.

The general practice is to plant tops. In case the supply is not sufficient, cane setts are planted. In the case of exotic canes it is not possible to use tops when they freely flower. In that case, cane setts are to be planted and this increases the cost of production as the canes cost very much more than tops. This is one of the reasons for the exotic canes not becoming popular. The general seed rate for the soft Pattapatti cane is 8,000 double setts per acre, and 4,000 for the hard Cheni cane. But in some places the seed rate varies between 6,000 to 12,000 (double setts).

There are two methods of planting in the State. In the southern part of the State setts are planted in pits and watered by hand till the rains set in. This method is mainly adopted in areas where there is not a sufficient supply of water for irrigation at the time of planting. In the other parts, setts are planted in rows of shallow trenches. In such an area there is plenty of water and water could be easily run into the furrows. The method to be adopted depends upon the conditions of the locality. If conditions are favourable planting in furrows far apart will not only reduce the cost of seed but would allow the use of bullock labour for cultivation and other purposes. But on poor soils and without proper manuring these methods are not satisfactory.

Sometimes a crop of garlic, onions or coriander is taken as soon as the canes are planted. The crops are harvested before the cane covers up the whole field. Good crops are sometimes harvested and it is said that these inter-crops meet the cost of cultivation.

No ratoon crop is generally taken though it is known to the ryot in the maidan or the open country. But in the Malnad it is fairly common. Sometimes good ratoon crops of thirty to thirty-five tons of cane are harvested and it is the belief in some places that the ratoon crop yields better than the first crop. In some cases a second ratoon also is taken. The ratoon crop matures early and gives a good profit, but it upsets the rotation and costs very much to clean the land after the crop is harvested. Especially where the

lands are valuable and crops of paddy could be taken it does not pay to ratoon.

Digging once or twice is practised in places where planting in pits is done but in other places only weeding and earthing up are done at the time of opening up of irrigation furrows. To keep the plots as clean as possible weeding is done often.

Generally the Pattapatti cane takes twelve months to ripen and keeps good for a month. But the same cane on heavy soils and under semi-Malnad conditions seems to take about fourteen months and in such areas there is demand for good early ripening cane. This need is to some extent satisfied by the Java cane. On the other hand Cheni cane is supposed to ripen in about eighteen months, but good jaggery may be made from it even if it is standing in the field for two years. If a cane ripens earlier than in twelve months it will be difficult to keep up the seed supply and there is the danger of a reduced yield. But very early ripeners may be useful for canal areas and small tanks where water supply is limited.

The commonest rotation is paddy after sugarcane. Under well irrigation garden crops such as turmeric and irrigated ragi are grown in rotation with cane. In the dry area where Cheni cane is grown, cane is followed by a cultivated fallow, and again cane is planted.

Manures.—Fifteen to fifty cart-loads of cattle manure are applied to an acre according to the quantity available. Honge flowers are largely used in the Kolar District. In some places small quantities of oil-cake are used, and this custom is now getting more and more popular. Castor and groundnut cake and ammonium sulphate are now being advocated, and being distributed by the Department, but if a greater demand sets in for cake a large number of oil mills becomes necessary in the State. If the idea of starting a cyanamide factory becomes a fact, then there is a chance for the ryot to get a cheap manure. Both Cheni and Pattapatti canes respond very well to heavy manuring. But a heavy dressing of manure seems to lengthen the duration of the crop and to increase the amount of glucose in the cane. Cane trash is not used as manure here but is used as fuel. In some places green manuring is done to paddy which is grown in rotation with cane. But in some cases large quantities of green leaves are dug into the furrows before planting. In

a few places where green manuring is done it seems to have a very good effect. In places where water is scarce it seems to increase the attack of white ants.

Diseases.—Smut and Leaf Spot disease are common on Cheni cane. Smut is very severe at the time of tillering and the ryot is of opinion that smut brings on heavy tillering. The smutted shoots are collected and removed from the field. The attack of wild animals, like jackals and pigs, is very common on the soft canes. The damage caused by them is very much in the Malnad.

Irrigation.—Sugarcane is an irrigated crop in this State. The sources of irrigation are :—(1) River channels : (2) Major and Minor tanks ; (3) Wells ; (4) Thalapariges or channels drawn from sandy streams. When the Kannambadi and Marikanve reservoirs and their channels are completed and the tanks are improved there will be a large supply of water. From January to May and August onwards irrigations are necessary. But water is found in river channels only between June and February. For every irrigation about an inch and a half of water is allowed into the field. Generally about fifty irrigations are given and if the rainfall is thirty inches the total water used comes to about 105 inches or about nine feet of water. In very dry places having only 19 inches of rain about ten feet of water are required. Except when cane is grown under wells and major tanks there is no sure supply of water and rarely small wells are dug to help the irrigation if the tank water fails. In some places hand watering is resorted to till the rains set in.

At present Government is helping the ryot to get pumping plants and cane crushing mills. The amount is recovered in five annual instalments. Under these conditions it is very hard to take the help of Government. Paying the interest, returning 20 per cent of the capital, meeting the cost of cultivation and manufacture, as well as his own maintenance are the items which the proceeds of the plantation have to meet. If the period is distributed over ten years and for the first year no call is made, the scheme may be more useful.

When there is an abundant supply of water and there is not enough labour and capital to grow cane, the ryot naturally takes to paddy, it being the easiest of crops to grow. Excessive irrigation coupled with bad drainage has been the cause for the alkalinity in certain areas. This is specially so in dry tracts. Rich dry fields

in the Marikanve tracts have become highly alkaline owing to excessive irrigation and bad drainage. Much of the cane areas under many tanks require good drainage.

Manufacture.—Cattle power is insufficient for effective milling of canes and this shortage is being felt keenly for the last five or six years. Animals that were costing Rs. 300 and Rs. 400 costs now as much as Rs. 900 and Rs. 1,200 or even more. To depend upon hired cattle for milling is not very safe now. Milling is considered hard work and the cattle owners do not like to overwork their animals and spoil them. This difficulty is greater in the case of improved mills which give a better extraction. Some mechanical substitution is becoming more and more urgent. Small portable oil-engines with a centrifugal pump and a mill crushing about one ton of cane per hour may be able to meet the requirements of a whole village. There are very few villages having more than 100 acres under cane at one time. Even smaller combinations might be tried to meet the requirements of small planters. It will be independent of cattle supply and the fields may be harvested in a much shorter time and probably a better extraction may be obtained. If any of the new type of tractors prove satisfactory for belt work, they will solve the problem of shortage of cattle power and also to some extent that of manual labour. Such ones will greatly help to start small plantations of 50 to 100 acres and open a new field for the students passing out of the various Agricultural Institutions. But for some time to come, these plantations are to be started and equipped with the help of Government and the money spent recovered in easy instalments, say in about fifteen years.

Mills.—There are still some two-roller mills but three-roller mills have become popular. There are very many types of three-roller mills in use and most of them are made in India and some of them are of local manufacture. They extract about 62 per cent with soft canes and about 55 per cent with hard thin canes and sometimes even less. Nahan mills from the Punjab have become very popular on account of the high extraction that could be got with bullock labour. On an average a 70 per cent extraction could be had from it with soft canes. The cultivator gets his mill and two pans on hire by paying Re. 1 or 1-8 per day. To mill a crop of say 30 tons it takes him 24 days and costs him about Rs. 40.

It is seen now in some parts that professional men go about the country with a complete outfit of a local mill and pans and do the milling and jaggery making on contract system. This is common in Hassan district: and if this system is developed, probably it will pay them to own a portable plant as it would enable them to deal with larger areas and make better profits. If by experiment it is proved that it is possible to work with small plants every facility should be given to land-owners to own such plants.

Jaggery.—Mysore exports large quantities of jaggery and soft raw sugar and is essentially an exporting country. Though it imports large amount of refined sugar for home consumption it exports much of unrefined sugar and jaggery. In 1918, the value of the products exported is a little more than double that of 1917.

1917—Export Rs. 25,41,937

Import „ 22,22,168

Net Export „ 3,19,769

1918—Export Rs. 28,60,219

Import „ 21,06,322

Net Export „ 7,53,897

This export is mostly in the form of jaggery and unrefined sugar. A very light coloured good jaggery is made in Bangalore and Kolar. In the southern part a black over-lined stuff is prepared and in the Malnad only liquid jaggery is made and preserved in pots. A bright coloured firm jaggery is now commanding a good market and it fetches nearly 8 to 12 annas more per maund than the ordinary stuff that is dumped in the market. Usually the price of jaggery was varying between Rs. 1-8-0 and Rs. 2-4-0 and that of sugar between Rs. 8 and Rs. 3-8-0, but as a result of the after effects of the war the prices of jaggery and sugar have gone up to Rs. 4-8-0 and Rs. 10 respectively, and for some period they were very much higher. Some white sugar is made by the local method and it fetches a higher price than the crystalline sugar in the local market. Of late some people have taken advantage of this and they make a kind of sugar by mixing crystalline sugar and unrefined sugar or sometimes light colored jaggery and grinding the whole thing to resemble local sugar. At present our sugar consumption comes to only about 8 lbs. per head and as we have a market for our produce outside the State, there is

no fear of glutting the market with sugar products by adopting improved methods and introducing greater efficiency.

So far under the present conditions sugar factories have not succeeded in the State. A detailed survey of the cane areas in the State may give information necessary to start a number of small factories. If the experiment proves a success our ryots who now combine for various purposes will see the advantage and take to the factory system.

No place in Mysore is at present capable of supplying a central factory with even 500 tons of cane a day. Even with a crop of 30 tons per acre a total area of 1,000 acres should be planted with cane to run the factory for two months at least. Taking a two years' rotation at least 2,000 acres are necessary. But making allowance for variation in soil fertility and varying yields, about 3,000 acres are wanted. There are only three places in Mysore where such large areas are found, but even there soil suited for sugarcane is scattered over the whole taluk. Unless new areas are opened specially for maintaining central factories and such areas are fully colonised and supplied with good roads, railway connection, and medical aid there seems to be very little chance for any big central factory in the State to spring up. Only drastic legislative measures could consolidate small holdings and create sufficiently large areas for somewhat smaller factories but ushering in new industries in this manner at the present time is neither safe nor possible.

As long as the ryot is capable of making his own jaggery and sell it in the market and get as much profit as possible he may not willingly sell cane to a factory. If the factory becomes a sort of a money lender to the ryot probably owing to the indebtedness he may sell the cane to the factory. On the other hand if the ryot is paid all the profits he would get if he sold the cane as jaggery, he may sell his cane to the factory but then it may not pay the factory.

As for selling the cane to the factory the ryot would like to sell by weight but the weight of cane gives no indication of either the ripeness of the cane or its sugar contents. The field of the ryot should be tested before the bargain is struck and according to the quality of the cane the price per unit may be settled.

In Mysore there are large areas of wild date (*Phoenix sylvestris*) and bhagani (*Caryota urens*) and they are the chief sources of toddy.

The plantations are all self sown and no attempt is being made to improve them and make them a source of sugar. In the Malnads a large area may be opened up for the bhagani palm. At present some jaggery is made out of its juice. Wild date grows very well under different conditions. It is found in rich well-watered valleys and on dry elevated places. Wide areas of arid tracts are studded with wild date and these areas may be profitably utilized by systematic planting and cultivation. Such areas are common round about Banavar and especially in Tumkur, Kadur and Chitaldrug districts. Cheap jaggery from these plantations may keep sugar factories going for some time longer during the year.

Some attempt was made to make raw white sugar direct from cane juice with the help of centrifugal machines. The disposal of molasses becomes a great problem and unless it is profitably sold it does not pay to make white sugar. But after the first spin a second grade of jaggery may be made by boiling down the molasses with the small amount of sugar that is left behind in it. This jaggery may get a price of Re. 1 per maund. If the price of jaggery goes above Rs. 2 per maund it does not pay to make sugar. On the other hand if the jaggery falls down below Rs. 1-12-0 and the price of sugar is above Rs. 3, it will pay well to make sugar. Roughly it comes to this that if the price of jaggery is nearly half that of sugar it pays one to prepare sugar. Much investigation has been done in this connection by the Department but still there is some controversy about it.

Trade.—The after effects of the war have completely upset the trade conditions. The average or normal conditions have not yet come back. Therefore for a safe guide conditions prevailing in 1917 are taken for the purposes of calculations as that year represents a normal one. Mysore is essentially a sugar exporting country. A large amount of refined sugar is imported into the State but a much larger quantity of raw or unrefined sugar and jaggery are exported. There is only one distillery in the State and large quantities of molasses are imported from outside.

Molasses.—

Import in 1917	1,40,480 mds.	Value Rs.	3,86,319
Export „	126 „	„ „	346
Net Imports	1,40,354 „	„ „	3,85,973

This large quantity of molasses imported might have been due to the large quantities of liquor made for the army. Anyhow the distillery being under State control its requirements might be met by a small sugar factory. Such a factory would not only give the necessary amount of molasses, but it will reduce to a certain extent the import of refined sugar and also be a place of training ground for students and the trade interested in the industry and afford opportunity for investigating the immediate problems connected with the utilization of the by-products of the sugar-house. In 1917 the amount of export over that of import was 23,943 mds. (82 2/7 lbs.) of sugar products valued at Rs. 21,20,813.

The following are the figures for 1917 :—

Refined Sugar :—

	Mds.	Value Rs.
Import	1,06,623	16,25,091
Export	15,806	2,10,023
Excess of import	90,817	14,15,068
<i>Un-refined Sugar :—</i>		
Export	1,24,576	13,05,068
Import	8,486	1,07,970
Excess of export	1,16,090	11,97,098
<i>Jaggery :—</i>		
Export	1,52,746	10,26,503
Import	13,722	1,02,788
Excess of export	1,39,024	9,23,715
<i>Molasses :—</i>		
Import	1,40,480	3,86,319
Export	126	346
Excess of import	1,40,354	3,85,973
Total Export of		
Sugar products	2,55,114	21,20,813
„ Import „	2,31,171	18,01,001
Net export „	23,943	3,19,812
(N.B.—One Md. = 82 2/7 lbs.)		

Sugar Production in the State :—

	lbs.
Total production of jaggery ..	70,926,816
Imports „ „ ..	1,129,129
Total ..	72,055,945
Export ..	12,568,614
Raw sugar exported in terms of jaggery (Sugar taken as 60% of jaggery) ..	17,618,591
Balance consumed in the State ..	41,768,740
Taking the population of the country as 5,948,353, the consumption (jaggery) per capita comes to	7.0
Refined Sugar	1.26
Un-refined Sugar	0.12
Total consumption ..	8.38

(Compare this with the amount consumed per capita in Europe.)
United Kingdom 87.318 lbs.

Conclusion.—The climatic and soil conditions in Mysore are eminently suited for sugarcane. It has been possible to secure high yields of even 60 tons of cane per acre with the help of better cultivation, manuring and the use of productive types of canes. The research side of the industry has been well organized. The much felt organization to bring the scientific workers and the actual cultivators together has been found in the Mysore Agricultural and Experimental Union. The progress made already in the State is mainly due to the enthusiasm of the members of the Union and the intelligent cultivators who are co-operating with the Department to develop this most important industry of the State. The meetings of the Union are sufficient to collect information and to impart instruction to members. The important need for the present is the organization, both of capital and labour, and a general survey of the present economic condition of the sugarcane planter. Further to extend and place the industry on a firm basis the following points require careful consideration by the public and the Government.

(1) A survey of all the waterpower in the Malnad. The construction of reservoirs and storage tanks will truly make Malnad

the granary of South India and increase the area under cane to a remarkable extent.

(2) Drainage of the Marikanve irrigated tract and opening it by extending the Railway beyond Chitaldrug to Hiriyur.

(3) Making a detail survey to store water in tanks alongside of river channels to supply water in summer.

(4) Organization of agencies to distribute to the ryots better types of canes, manures and implements.

(5) Organization of Land Banks and co-operative societies to finance the ryot to buy his requirements and sell his produce.

(6) Opening up of colonies for the trained Agricultural students, who are passing out of the colleges.

These are the points that require our immediate consideration. A well thought-out plan and a vigorous programme with properly equipped agencies to carry out the work are the factors that are needed now. Can we get them? The materials are available, but will the country make use of them? Here is an opportunity for educated young men to set up independent concerns and for the Government to provide facilities for such to set bold examples. We have faith in the people, the Government and the future of this important Industry.

Sugarcane in Mysore.

PART II.

BY

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Ripening of cane and deterioration after reaching maturity.

Investigations as to the ripening of the most extensively grown variety of cane in Mysore—the local striped or “Pattapatti”—were started by Dr. A. Lehmann, the then Agricultural Chemist, in the year 1905 and continued for a number of years. It was found that the “Pattapatti” cane ripened ordinarily at the end of 12 months after planting and that the composition of juice from it remained

constant for about a couple of months after that as seen from figures given below :—

Week of harvest season	Composition of juice		
	Sucrose	Glucose	Solids
	%	%	%
1st week	20.25	0.41	21.02
2nd „	20.76	0.33	21.37
3rd „	20.89	0.44	21.71
4th „	20.60	0.46	21.51
7th „	20.96	0.50	21.88
8th „	20.73	0.68	21.82
9th „	20.49	0.67	21.50

Varieties differ very materially in the rate at which they deteriorate after maturity. In one of the varieties grown on the Hebbal Farm, the individual canes showed a variation of only 0.75% in their sucrose content during 4 months' time. During all that period, the juice showed a sucrose content of 21.0% or more. Another variety remained comparatively constant in quality for 6 weeks. During that time, the individual canes varied about 1% in sucrose content, *viz.*, from 19.8 % to 21.0 %. Two other varieties again deteriorated very rapidly. Naturally, it is desirable to cultivate such varieties which, other things being equal, remain at their best for the longest time.

On one of the large estates in the neighbourhood of Bangalore, there was a very general arrowing of the local varieties of cane in 1910, and the opportunity was utilized to find out the differences in composition of juice from arrowed as well as not arrowed canes. The results then obtained are tabulated on p. 155.

These figures show that though the juice from arrowed canes is superior at the start to that from canes which have not arrowed, the arrowed canes also improve in quality and that in about a couple of months, the quality of both reaches the same standard.

Extraction tests conducted at the same time showed that the arrowed canes do not become pithy while they are still improving in quality, so there does not seem to be any reason for unduly hastening the milling operations soon after canes begin to arrow.

Name of variety	Composition of juice from						Date of analysis
	Arrowed canes			Not arrowed canes			
	Solids	Glucose	Sucrose	Solids	Glucose	Sucrose	
	%	%	%	%	%	%	
1. Local Striped	19.71	0.71	18.25	18.24	0.77	17.10	5-12-10
	20.09	..	19.70	19.09	..	17.75	17-1-11
	20.03	0.50	19.30	20.00	0.50	19.10	1-2-11
	21.90	0.28	21.50	21.60	0.28	21.25	17-2-11
2. Rastalay Cane	18.44	1.00	16.90	17.64	1.25	15.90	5-12-10
	20.51	..	19.25	19.64	..	18.75	17-1-11
	19.64	1.00	18.65	19.24	1.00	17.80	1-2-11
	20.51	0.61	19.95	20.65	0.60	20.10	17-2-11
3. Chitta Rastalay Cane	18.24	0.44	17.30	16.24	0.67	15.10	5-12-10
	18.78	..	17.90	18.38	..	17.25	17-1-11
	19.44	0.28	18.65	18.78	0.33	17.85	1-2-11
	18.64	0.26	18.00	18.78	0.28	18.20	17-2-11
4. Cheni Cane	17.51	0.71	15.60	17.57	0.67	15.80	5-12-10
	18.71	..	16.60	18.64	..	16.90	17-1-11
	16.98	1.25	14.45	17.65	1.11	15.40	1-2-11
	19.90	0.55	18.75	18.50	1.00	17.00	17-2-11

Lodged cane.—While harvesting sugarcane on the Hebbal Farm in 1907, it was found that a portion of the field had lodged very badly and that portion was harvested and analysed separately to find out the yield of cane as well as composition of juice from it. It was found that the yield from the lodged part of the field was only two-thirds of that from the area in which the cane was standing erect. The juice from erect canes contained 20.59 % sucrose and 0.47 % glucose while that from lodged canes contained only 15.1 % sucrose but 2.15 % glucose. This indicates the amount of loss due to lodging of cane—a loss due not only to decrease in yield but also to the inferior quality of the product obtained.

Effect of stunted growth on the composition of cane.—It is a popular belief that stunted cane is much the richer. To get some information on this point, one strip of five rows of "Pattapatti" cane was divided into three equal parts and each part harvested and analysed separately. All the cane was cut and analysed on the same day with the following result :—

Description of sample	Weight of cane har- vested	Yield per acre	Fibre in cane	Juice	
				Sucrose	Glucose
	lbs.	Tons	%	%	%
Southern Third ..	198	6.89	11.43	21.05	0.19
Middle Third ..	650	22.63	10.45	21.65	0.38
Northern Third ..	904	31.47	11.92	20.10	0.68

The middle third of the rows is about an average crop. It has a higher sucrose content and a lower fibre content than either the other two. The composition of juice indicates that stunted cane is not always richer in composition than normal cane.

The yields given in the above table incidentally give us an idea of the influence of drainage on sugarcane. The northern side of the plot harvested is better drained than the southern side, and has given a much heavier crop than either the southern third or the middle third.

Manufacture.—The type of mill that is generally used is an iron three-roller mill made in Bangalore or Madras. The old wooden mills have long been superseded by these. They are not generally owned by the cane-growers themselves. Mills and pans are usually hired out by those who keep them for the purpose. In some parts of the State, people with mills and pans and the necessary cattle go round and take on contract the milling of the cane crop. The efficiency of these mills leaves much to desire. According to the tests made by the Department and published in several annual reports as much as 20 to 38 % of the juice contained in the cane is left in the bagasse. In recent experiments conducted, the extraction from these mills varied from 58 to 67 % on the weight of cane. Taking 10 % fibre in the variety of cane used for these tests, from 25 to 35 % of the juice contained in the cane is still left in the bagasse. A new type of mill introduced, the "Nahan" mill made in the Punjab, is slightly more efficient, the average extraction being 68 to 69 % on the weight of the cane ; of course all the above figures are true only for the variety of cane (*Pattapatti*) used. Its capacity

also is slightly greater than that of the mills usually in use in the country.

The next type of mill introduced and tested is a power-mill made by A. W. Smith & Co., Glasgow, having three horizontal rollers 18" by 12" and driven by an oil-engine. The mill has been working at Ooragahalli estate since 1906 without any repairs or renewals. It has a capacity of one ton of cane per hour and gives an extraction between 72 to 78 per cent on the weight of the cane (*Pattapatti*). In 1913 the Department of Industries and Commerce set up similar mills made by Massey & Co., Madras. The capacity of two of those mills varied from 1,500 lbs. to 3,000 lbs. of cane per hour, and the extraction from the three mills tested ranged from 60 to 72 % on the weights of the cane (*Pattapatti*). These are some of the figures which show clearly what an enormous field there is for the introduction of improved mills and thereby saving a lot of wastage. This saving means an increased out-turn, even without an increase in crop.

The kind of pan generally used for boiling the juice is a round one with flaring sides, the smallest pans being capable of boiling about 300 lbs. of juice. In an average size of pan about 600 lbs. of juice are boiled. The methods of liming vary to a great extent. In the Malnad, where mostly semi-solid jaggery is manufactured, the juice is not limed at all. In the districts of Bangalore and Kolar, very great care is taken about liming, and the jaggery produced is generally of a good light colour and pretty hard too. Lime is used as a fairly thick cream. In some parts of the Mysore District, very thin lime cream is used. Powdered lime is also used in some parts of the Province.

Skimming is resorted to mostly where jaggery of a good light colour is produced, that is, in the districts of Bangalore and Kolar. In the Mysore District, which produces mainly dark jaggery skimming is done only when jaggery is made specially for domestic consumption.

The losses that occur during boiling have been studied in detail and extensive determinations of glucose and sucrose have been made. The average amount of inversion that takes place while boiling juice,

limed to neutrality is about 5 per cent of the sucrose contained in it. When properly skimmed to produce a firm and light coloured jaggery about 2 per cent of sucrose in the juice is lost.

In making jaggery the single furnace system is usually adopted. Begasse and trash are used as fuel for evaporating the juice. The available quantity of these two not being sufficient for the purpose, firewood is also used in small quantities to supplement the same. Experiments conducted to find out the quantity of fuel needed have shown that one ton of good dry fuel (fire-wood) is needed to boil down 6,000 lbs. of juice containing 20 per cent solids in solution. Attempts are being made to construct a simple but efficient form of multiple furnace with a view to utilize the heat of the waste gases and save fuel. The multiple furnace system makes skimming easier and renders it possible to filter the syrup without much difficulty, thereby improving the colour of the jaggery produced.

Ever since its establishment, the Department of Agriculture in Mysore has been devoting much attention to the manufacture of raw crystalline sugar direct from the juice. Statistics show that the imports of sugar into India are increasing by leaps and bounds. In a country which produces a cane like the "Pattapatti", where the methods of extraction are far from being perfect, there is ample scope to increase the recovery of the sugar contained in the crop grown. How far it is possible to manufacture sugar on a commercial scale with the existing mills and open-pan boiling, has been studied in Mysore in very great detail. It has been established beyond doubt that it is quite possible to produce white sugar fit for consumption from the juice direct, without any special process of bleaching it. The chief point is about the comparative yields of jaggery and sugar from the same quantity and quality of juice. The disposal of the molasses too is a difficult problem. Second recovery sugar is not fit for consumption without being refined. Jaggery made from molasses is too dark and has a peculiar taste, not quite pleasant. The only objection against fermenting it and distilling is that our object is to produce sugar and not alcohol. Moreover the extra capital and labour needed to produce sugar uneconomically increases the cost of production.

In the method tried for sugar-making, the juice was fully limed.

Another process of making sugar known as "Hadi process" was attracting considerable attention, and it was resolved to make comparative trials of the two processes. The results of the experiments have been published in the report of the Department for 1906-07. The sugar obtained by the "Hadi method" was in no way superior to that produced from juice fully limed. Liming the juice has other advantages, namely, that of decreasing inversion and thereby increasing the percentage of sugar recovered. As mentioned in the report above referred to, the inversion in the "Hadi process" amounted to over 22 per cent of the sucrose in the juice whereas by the other method it was only 6.59 per cent. About 42 per cent of the sucrose contained in juice was recovered as sugar when the juice was fully limed whereas only 39 per cent by the "Hadi process."

A large scale experiment on jaggery *versus* sugar-making was conducted by the Department on Ooragahalli estate in 1911 and the results are given below. It is seen that the weight of sugar obtained was only 9 per cent of the weight of juice used for boiling whereas 20 per cent of it was obtained in the form of jaggery. The loss due to inversion amounted to 10.3 per cent in sugar-making, whereas it was only 5 to 7 per cent in jaggery making.

OORAGAHALLI EXPERIMENTS IN 1911.

Sugar-making in Departmental set of 3 pans.—

Weight of juice boiled	.. 25,550 lbs.
.. massecuite	.. 5,426½ lbs. or 21.23 per cent on juice.
Total sugar obtained	.. 2,249 lbs. or 41.5 per cent on massec. or 9.0 per cent on juice.
Sucrose contained in juice	.. 4,500 lbs.
.. recovered in sugar	.. 2,168 lbs. or 48.2 per cent.
.. lost in scum	.. 1.5 per cent.
.. lost by inversion	.. 10.3 per cent.

Jaggery from Departmental set of pans (multiple furnace system).—

Weight of juice	.. 3,737 lbs.
Weight of jaggery	.. 712½ lbs. or 19.07 per cent on weight of juice.
Inversion during boiling	.. 5 per cent sucrose in juice.

Jaggery from Mr. Krishnaiengar's round pans.---

Weight of juice boiled	.. 11,850 lbs.
Weight of jaggery obtained	.. 2.419 lbs. or 20.4 per cent of juice.
Inversion during boiling	.. 6.94 per cent of sucrose in juice.
Lost in scum	.. 2.15 per cent of sucrose in juice.

Average composition of juice from "Pattapatti" cane used for above experiments :—

	Solids	Sucrose	Glucose
	%	%	%
For sugar-making	19.05	17.50	0.90
Jaggery making in Departmental pans	19.03	17.59	0.82
Jaggery making in Mr. Krishnaiengar's pans	19.12	17.59	0.82

The investigations up to the present have all shown clearly that with the crude methods of milling the cane and evaporating the juice, even though it is quite possible to produce white sugar fit for direct consumption, the percentage recovery of sucrose as marketable product is not large and that the losses are great. With improved machinery and modern appliances, these losses will no doubt be minimised. Even for jaggery making on a large scale the open pan system of boiling is not efficient. There being not much control over the heat, it is very difficult to prevent charring and produce a jaggery of a uniform light colour. For a cane planter with 30 or 40 acres under cane each year, a steam evaporation plant might come in very handy even for jaggery making.

Such a steam plant has recently been set up by the Department of Industries and Commerce on Ooragahalli estate. The equipment consists of 3 rectangular eliminators with a steam coil in each for heating and clarifying the juice, 2 round evaporators with 2 steam coils in each for concentrating the clarified juice and a Wetzell pan with a rotating steam coil for boiling down the concentrated syrup from the evaporators into jaggery. The steam necessary for the operations is supplied at about 60 lbs. pressure by a boiler supplied for the purpose. The fuel used for generating steam is partly fire-wood and partly bagasse. It is a pity that the erection of the

plant, excluding the Wetzel pan, could not be finished before the tail end of the milling season. Consequently, the eliminators and the evaporators were worked only during the last two days and the concentrated syrup was boiled down into jaggery in ordinary round pans over an open fire.

The three-roller mill owned and worked by Mr. Krishnaiengar for over 15 years is driven by an oil-engine and is just enough to supply the eliminators with the necessary amount of juice. While one of the eliminators is being filled with juice, the second one is used for heating and clarifying the limed juice contained in it, and clarified juice from the third one is being run into one of the evaporators. After steam is turned on, the limed juice remained in the eliminators for about one hour. About 30 minutes after turning on the steam, the "blanket" forms on the surface of the juice and is at once skimmed off into a gutter attached to it. Further skimming goes on during the next 15 or 20 minutes after which the juice is allowed to settle for about 10 or 15 minutes and then run off into one of the evaporators.

Each evaporator takes up juice from two of the eliminators. Steam is turned on in one of the evaporators soon after clarified juice from one of the eliminators is run into it. In about half an hour's time, juice from another eliminator is run into the same evaporator. The clarified juice from two eliminators concentrates in one evaporator for about two hours, after which time it is ready to be emptied into the Wetzel or the local round pan.

Since the Wetzel was not ready for operation, syrup from one of the evaporators was run into 4 round pans and boiled down into a consistency required for jaggery in about 45 minutes, cooled and put into moulds as usual—about 15 to 16 maunds of good jaggery being produced each time according to the quality of juice boiled.

Use of oil-cake as manure for sugarcane.—Comparative trials of honge and castor cake as manure for cane were started on the Hebbal Farm in 1916 and continued for a number of years. Various doses of oil-cakes were applied in addition to a dressing of cattle

manure at the rate of 30,000 lbs. per acre, and the results obtained are as follows :—

Manure applied.	Yield of cane in tons per acre.				
	1916-17	1917-18	1918-19	1919-20	1920-21
1. Only cattle manure	10.7	15.52	22.25	26.12	18.39
2. Do. & 1 ton honge cake	19.2	20.78	Discontinued.		
3. Do. & 1 ton castor cake	20.3	24.26		do.	
4. Do. & 2 tons honge	21.6	25.70	34.47	34.98	33.5
5. Do. & 2 tons castor	24.9	28.33	34.93	35.47	32.5
6. Do. & 3 tons honge	..	..	47.46	36.84	35.7
7. Do. & 3 tons castor	..	..	48.55	37.66	38.5

N.B.—The local Pattapatti was used for planting in the first two seasons, and Red Mauritius afterwards.

The slight superiority of castor cake over honge cake is seen from the yields given above. The three-ton dose of cake has been found beneficial in only one year, *i.e.* 1918-19. Financially considered, the three-ton dose seems to pay only in years of favourable rainfall.

Influence of sulphate of ammonia on the tillering and growth of cane.—This experiment was started in 1920 on the Hebbal Farm in a plot used for testing varieties of sugarcane. The manuring was so planned that for each variety there were 9 plots receiving only groundnut cake at one ton per acre and 9 others receiving sulphate of ammonia also at the rate of 250 lbs. an acre equivalent to 50 lbs. nitrogen. Each of these small plots is 1/225 acre in extent and only the average results from all the 9 plots are given below. Naturally there has been some variation in yields from plots treated in a similar way, but on

the whole, the sulphate plots have uniformly given a higher yield per acre as seen from the table below :—

Variety.	Yield of cane in tons per acre.			
	Check plot.		Sulphate plot.	
	1920-21	1922-23	1920-21	1922-23
Red Mauritius	34.1	34.8	46.3	43.1
H. M. 14	27.4	..	34.5	..
H. M. 544	39.9	..	48.4	..
H. M. 310	24.7	..	34.3	..
H. M. 312	41.6	..	55.7	..
H. M. 320	..	44.6	..	45.1
H. M. 332	..	38.2	..	43.0
H. M. 313	..	37.5	..	42.0
H. M. 353	..	35.6	..	39.7

These are surely very clear indications of the effects of the manure applied. Some of the varieties have responded more than others.

To test these results on a large scale and under different conditions of soil and climate, similar experiments were undertaken in co-operation with some of the members of the Mysore Agricultural and Experimental Union. The results of a few such trials have already been published in Vol. IV, No. 2. pp. 75-78 of this Journal and are here summarized without any comments for the sake of convenient reference :—

Locality	Variety	Yield of cane in tons per acre	
		Check plot	Sulphate plot.
Ooragahally	Local striped	15.0	17.0
	H. M. 544	25.0	33.0
Honnur	Red Mauritius	27.0	33.0
Talagavara	Local striped	25.0	34.0

Manurial requirements of sugarcane.—These experiments were started on the Babboor Farm in 1920-21. As it was thought advisable to study the effect of liming also on the soil, the plots have all been duplicated. In all there are 40 plots and 20 of them have been given ground lime-stone at the rate of 2 tons per acre. The

whole area receives a general dressing of ground-nut cake at the rate of one ton per acre. The plan of manuring with artificial manures is as follows :—

- (1) No special manure.
- (2) Complete mineral manure.
- (3) Mineral manures without nitrogen (ammonium sulphate).
- (4) " " phosphate.
- (5) " " potash.

Each treatment has been repeated on four different plots with lime and on four others without lime.

A 30-ton crop of Pattapatti cane on the Hebbal Farm removed 70 lbs. nitrogen, 85 lbs. phosphoric acid and 230 lbs. potash from the soil. Taking this as a sort of indication and based on the experience of other countries, nitrogen in the form of sulphate of ammonia has been applied at the rate of 50 lbs. per acre. This combined with the organic nitrogen of the oil-cake, the availability of which is rather slow, ought to be quite enough for the requirements of the crop. Phosphoric acid in the form of ordinary superphosphate has been given at the rate of 75 lbs. per acre. Potash as sulphate of potash has been applied at 60 lbs. per acre. As the soil itself is not poor in potash it was not thought advisable to give heavy doses of this costly manure.

The results of three seasons are tabulated below for comparison:—

	Yield of cane in tons per acre.					
	Unlimed series.			Limed series.		
	1921	1922	1923	1921	1922	1923
Check plot	19.6	13.0	24.3	22.3	12.3	24.7
Complete manure	22.0	18.7	31.8	23.5	17.5	33.1
Without nitrogen	23.3	11.5	30.3	22.7	11.6	31.3
Without Super	21.0	14.4	30.4	23.0	14.0	31.4
Without potash	25.6	16.6	32.8	25.6	14.4	34.5

N.B.—Variety of cane planted—Red Mauritius for 1921 and 1922 and J.33A for 1923 series.

The three crops harvested till now have been grown on three different sets of plots. During the first two seasons the whole experimental area was manured uniformly with one ton of ground-nut cake per acre and the variety of cane planted was Red Mauritius. For the 1922-23 experiments a green manure crop of sunn-hemp and cow-pea was grown on the field and ploughed in before planting cane. The usual dose of one ton of cake was also given. Red Mauritius not having been found particularly suited to the tract in which the Farm is situated, J.33A was used instead for planting.

The artificial manures applied have shown their good effect in all the three seasons. The omission of either nitrogen or phosphoric acid has tended to decrease the crop generally. In two of the years those plots which did not receive any potash at all have given the highest yields. In the same two years, the limed plots also have given better yields than the unlimed ones.

Taken as a whole, the results of these three years' work indicate that nitrogen, phosphoric acid and lime are needed for sugarcane on the type of soils on which the experiments were tried at Babboor. When another set of results have been obtained on the same series of plots, the question of actual quantities of sulphate of ammonia and super needed to grow sugarcane profitably on lands represented by the Babboor Farm, will be taken up.

Similar experiments on a slightly modified plan were started on the Marthur Farm also in 1921 and continued in 1922. The trial of potash also had been included in 1921, but discontinued in 1922. The variety used for planting was Red Mauritius and the results of the two years' experiments are as follows:—

Treatment.	Yield of cane in tons per acre.	
	1921-22	1922-23
Only cake	6.0	8.1
Cake and Super	8.5	13.4
Cake and Sodium Nitrate	7.5	3.0
Cake, Sodium Nitrate and Super	12.0	6.4
Cake and Ammonium Sulphate	8.0	7.8
Cake and Ammonium Sulphate and Super	9.3	12.3
Extra cake	..	15.0
Extra cake and Super	..	18.2

The effect of superphosphate on the cane crop is clearly seen from the yields given above. Ground-nut cake was applied to the whole area at one ton per acre and an extra dose of 625 lbs. per acre to some of the plots in 1922-23 to compare its effects with the same amount of nitrogen given to the other plots as ammonium sulphate or sodium nitrate. The results above indicate that extra nitrogen given in the form of cake is more beneficial than the same applied in the form of ammonium sulphate or sodium nitrate. This result remains to be confirmed before the experiments can be modified.

Similar experiments to find the influence of phosphatic manure applied at the rate of 300 lbs. superphosphate per acre, on yield of cane were conducted in 1922-23 on a fairly large scale on the Hebbal Farm with H.M. 544 and on Ooragahalli estate with local striped cane. The whole area had been manured with one ton of ground-nut oil-cake and 250 lbs. ammonium sulphate per acre in addition to green manure at Hebbal and cattle manure at Ooragahalli. The results of these experiments are as follows :—

<i>Locality</i>	<i>Variety of cane</i>	<i>Treatment</i>	<i>Yield per acre</i>
Ooragahalli	Pattapatti	With Super	438 } Maunds of
Do.	do.	No Super	405 } jaggery.
Hebbal	H.M. 544	With Super	46.04 } Tons of
Do.	do.	No Super	46.58 } cane.

The work is being continued and the results obtained will be published in due course.

NOTES AND COMMENTS.

Phosphatic Manures.

That phosphoric acid is one of the indispensable plant-foods is a well established fact. The insufficient supply of soluble phosphatic manures in Germany, during and after the war, stimulated research as to the methods of overcoming the difficulties without at the same time bringing about a diminution in yields. As a result of these researches, a new system of manuring—called the Aerabac Wrangell system—which dispensed with the use of soluble phosphates imported from abroad began to be advocated. A big controversy in which a large number of Germany's famous agricultural chemists took part sprung up about this new system of manuring, and the whole position has been reviewed by Prof. F. Honcamp of Rostock in the German Journal of Applied Chemistry, No. 55 of 18th July 1923. He concludes by saying that the new system which advocates the use of physiologically acid manures such as sulphate of ammonia, and sulphate of potash, the discontinuing of the periodical application of lime, and the getting rid of lime in the soil by applying chloride of potash to bring about a certain amount of soil acidity for liberating the phosphoric acid of soils is likely to do more harm than good in the majority of instances. Further, he says that the conditions of soil and plant-growth are so varied that it is not possible to lay down hard and fast rules as to when phosphatic manuring is necessary and when it is possible to make the soil phosphate available to plants by indirect means. He fully concurs with Paul Wagner, one of the most successful investigators in Germany in the field of plant nutrition and manuring of plants, who characterized the phosphate question as one of the most complicated and trying of all problems connected with agriculture.

It may not be out of place here to bring to the notice of our members the name of Paul Wagner whose birthday was recently celebrated in Germany. He has been the director of the experimental station of Darmstad since it was started more than 40 years ago. It is he that developed pot culture work to its present high

standard of accuracy and efficiency and contributed materially to our knowledge of plant nutrition and manurial requirements of soils and plants. The results of his investigations have been widely published not only in Germany but in America also to the vast benefit of agriculture in both the countries. [B. N. I.]

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Rice Experiments in California.

According to Bulletin No. 1155 of the U. S. Department of Agriculture, more than half a century ago, attempts were made to grow rice in California but they were not successful. The rice industry in that State first assumed commercial importance in 1912, and in the same year "The Biggs Rice Field Station" also was established. The results of some experiments conducted there have been published in the bulletin above referred to, and the following are some of the conclusions arrived at:—

1. "In the depth of seeding experiments, shallow seeding was found to be better than deep seeding."
2. "In the time of submergence experiments, submerging 30 days after the plants emerged gave the highest yield."
3. "In the depth of submergence experiments, the highest average yield was obtained by submerging the land 6 inches deep during the submergence period."
4. "Slowly changing water gave a higher average yield than stagnant water. Fluctuations in the depth of submergence gave a higher average yield than slowly changing or stagnant water."
5. "The wet irrigation practice consists of irrigating the rice as often as necessary until 30 days after emergence; then submerging the land 6 inches deep continuously until the crop is ready to drain after harvest."
6. "The fertilizer experiments indicate that non-nitrogenous ones are unprofitable while all nitrogenous ones except nitrate of soda produced increased yields which were profitable."
7. "Combinations of nitrogenous and non-nitrogenous fertilizers did not increase the yields as much as when the nitrogenous ones alone were applied."

[B. N. I.]

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Manurial Experiments with Rice.

During the early part of this year pot experiments with paddy were carried out in the pot culture house at Bangalore. A heavy clay soil was used for filling the pots and 30 days' old seedlings of *Chintamani Sanna Bhatta* were transplanted into them. The manures tried were sulphate of ammonia, dried blood, groundnut cake, safflower cake and castor cake. These nitrogenous manures were used by themselves and along with bone-meal and superphosphate also. The addition of super showed a remarkable effect on the crop, not only on its growth but with regard to the ripening of it as well. In fact the series manured with super was harvested about 4 weeks earlier than the others.

The maximum crop was obtained from pots manured with ammonium sulphate and super. Sulphate of ammonia used by itself or in combination with bone-meal failed to enable the crop to produce any grain at all. The use of castor cake along with bone-meal seems to have had a great influence on making the phosphoric acid in bone available to the crop. We hope to publish a detailed report of the experiments in our next number. [B. N. I.]

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The Lime-tree Borer.

(*Chelidonium cinctum*.)

The following illustration of the Lime-tree Borer was received too late for insertion in the body of the article appearing elsewhere. It is printed below to enable readers to identify the insect more easily and pick off and destroy it when it is seen on or about lime trees in the months of June and July.



THE LIME-TREE BORER.

The Amrit Mahal Department.

This Department has recently come under the Director of Agriculture and is under the immediate supervision of the Live-Stock Expert. We need not say that the main purpose of that Department till now was the production of draught bullocks for the transport of artillery. The famous Duke of Wellington came to know of the merits of the breed during his campaigns against Hyder and Tippu, and regretted their absence very much during his campaigns against Napoleon. In one of his despatches, he mentions that the bullocks of the Amrit Mahal breed were under the yoke for 30 hours at a stretch and never failed him in his hour of need.

The transfer of the control of this famous herd of cattle to the Live-Stock Expert opens out a wide field for carrying on breeding experiments for the general improvement of draught cattle in the State and we wish Mr. Davison every success in his endeavour in that direction.

[B. N. I.]

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The Indian Science Congress.

This meets for the second time in Bangalore in January of next year and we hope that the Agricultural section of it will in no way lag behind the other sections both in the quantity as well as quality of its contributions.

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Board of Agriculture.

Immediately after the close of the Science Congress comes off the meeting of the Imperial Board of Agriculture too in Bangalore. To all those interested in Science, and particularly in Agriculture, January promises to be a very busy and interesting month and we hope our members will take full advantage of both the important meetings in Bangalore.

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Sale of Good Breeding Cattle of the Amrit Mahal Department.

Elsewhere in this number, we are publishing a notification which outlines the possibility of obtaining good breeding cattle. In our official capacity, we are in receipt of numerous enquiries regarding the possibility of obtaining good bulls, cows, etc., at the cost. Up until recently it has been difficult, in fact impossible, to give satisfaction on these points. It is now possible for the demand to be met, at least in some measure. On account of numerous working difficulties,

which it has not been possible to overcome as yet, the method of supplying and obtaining animals from the Amrit Mahal Department, is not entirely satisfactory in several respects. Some of these defects will be overcome in the course of time, and it is hoped that in the meantime advantage will be taken by as many of our readers as are interested in the production of better cattle and that they will come forward to take advantage of the present facilities.

There is good reason to believe that the future will hold out a permanent demand for good cattle at profitable prices, and the man who builds up for himself a herd of well-bred, sound and reliable breeding cattle, is laying down for himself an investment which will be a source of pleasure as well as profit. No better cheaper method of doing this can be adopted than the purchase of a select herd of young heifers and a sound and well-bred bull to mate with them. The opportunity now available may never again occur. [W. D.]

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Our Annual Meeting.

The Sixth Annual Meeting of the Union has been decided to be held for four days commencing from Thursday the 13th December, 1923. The details of programme, etc., will be intimated to members in due course. There will be a sale of bull calves from the Hebbal Dairy herd and a number of Amrit Mahal bull calves will also be offered for sale to members.

CORRESPONDENCE.

The Poorest Holding in the Village—a Reply.

“Which is the poorest holding in the village? How many have put themselves this question, or attempted to find an answer?”

So asks Dr. Kunhi Kannan in a note published in the last number of the Journal of the Mysore Agricultural and Experimental Union. In his opinion, no question is more important than this in Indian agricultural economics, and he believes it to lead to a correct estimate of the present state of the ryot, and to an efficient handling of agricultural problems. It seems to me that his entire argument is based on a misconception of the phenomenon known as the downward movement of the margin of cultivation. He thinks that the progressive utilization of lower grades of land causes a deterioration of standards of life, and consequent degradation of the agricultural population. He apprehends that people are “driven” to poorer lands by a fatal

necessity ; he speaks of the decay of industries as throwing men back on land as "the sole resource left to them". This is luridly graphic, but fortunately by no means true. It is not a fact that industries are decaying, nor is the cultivation of lower grades of land a fateful downward rush of the human race. It is almost a truism in economics that it is the progressive rise in the prices of agricultural produce that causes the margin of cultivation to descend. This is a constant tendency, though its operation is sometimes masked by supervening causes such as improvements in cultural methods, and availableness of new sources of supply. Agricultural prices themselves are governed by the laws of supply and demand. Speaking generally, the price of the whole supply is that of the most expensively produced part of it—that is to say, of the part raised on the poorest grade of land under cultivation. Dr. Kunhi Kannan seems to have overlooked this, for he assumes prices to remain constant, and argues that each downward step of the margin of cultivation takes place at the cost of the unfortunate cultivator. Look at the illustration he gives of his conception of rent. "D" is the grade of land which just repays cultivation by bringing in a return of Rs. 125 an acre from which I take it that the cost of cultivation is Rs. 125 an acre. "If now as a consequence of increased pressure on land" says Dr. Kunhi Kannan, "the land in the next poorer division E is taken up, it will yield only Rs. 100 an acre, with the result that D which yielded no rent before, now begins to yield one of Rs. 25." How could this happen, unless the produce of D which was formerly worth Rs. 125 increased in value to Rs. 150 ? The argument also assumes that the cultivator of E will be content to spend Rs. 125 (the cost of cultivation, by hypothesis), for a return of only Rs. 100. There is some comfort in the thought that this disastrous ryot cannot continue long in his folly.

It is small wonder that this fundamental misconception should give rise to an erroneous theory of rent. The first result of increased pressure on land would be a rise in agricultural prices. As prices rose the produce of an acre of land 'D' which before was worth Rs. 125 would increase in value, and the extent of this increase would be a measure of the rent which would accrue. As the upward course of prices continued, a point would be reached when the smaller yield of an acre of grade E would be worth Rs. 125, the cost of production ;

and *only then, and not earlier*, would this grade of land be cultivated. Rents rise with the downward movement of the margin of cultivation no doubt, but this rise does not take place on degraded lives or broken home-steads. It is a groundless fear that "with this lesser amount the poorest family has to live" or that "the wages of day-labour will also have been decreased". In fact, though the margin of cultivation is steadily descending in all old countries, everywhere the wages of labour are going up with equal persistence. I should here advert to another curious prediction—that even the decreased wages of labour prophesied as the result of the calamitous cultivation of land E will be more than the income from that land which must be admitted to be probable, if the income from E is *minus* twenty-five rupees an acre.

Before quitting the subject of rent, it must be noticed that Dr. Kunhi Kannan visualizes the ryots as sending up rents by competing keenly for leases of good land. This scramble for leases may be true of tenements in England, but is certainly not true of ryotwari Mysore. Lands are normally not available for lease except in a few unfortunate *Agraharams* or other localities curst with absentee proprietorship; and even here the ryot is more often the tyrant than the victim of the situation. Lands cultivated by lessees are notoriously the worst looked after in the village.

I confess to something more than a doubt whether the enquiry so earnestly recommended by Dr. Kunhi Kannan would lead to any useful result. The most unproductive holding in real life would probably nowhere be "either wholly or almost wholly" the means of its proprietors' livelihood. The income from it would be found to be supplemented by the profits of trade or other occupation, or the wages of agricultural or other labour, as is indeed to be expected in an economy dependent on the seasons. Perhaps the wages of unskilled labour, as the marginal value of a unit of population, might furnish an index of the state of the lowest economic stratum of the human factor. But after all, would this knowledge go very far in solving agricultural problems? A full investigation of the economic life of the village, which included in its scope all grades of the village community, would no doubt be a useful preliminary to constructive work or policy; but if one is to rest content with less comprehensive data, large averages seem to be infinitely preferable to a curious

knowledge of extremes. There may be a melancholy interest in ascertaining the circumstances of the poorest family in the village, but the information would hardly be more valuable than the dimensions of its smallest inhabitant.

N. Rama Rao.

Rejoinder.

I am not quite sure if Mr. Rama Rao has ever crossed what Mill calls the *pons asinorum* of political economy, viz., the Ricardian theory of rent which has survived more than a century of criticism. If he has not, I shall help him to do so by quoting the theory from Mill. Here is the passage:—"On the first settling of a country in which there is an abundance of rich and fertile land, a very small portion of which is required to be cultivated for the support of the actual population, or indeed, can be cultivated with the capital which the population can command, there will be no rent, for no one will pay on the use of land when there is an abundant quantity not yet appropriated and therefore at the disposal of whosoever might choose to cultivate....". But when in the progress of society, land of the second degree of fertility is taken into cultivation, rent immediately commences on that of the first quality and the amount of that rent will depend on the difference in the quality of these two portions of land.

"When the land of the third quality is taken into cultivation rent immediately commences on the second and it is regulated as before by the difference between the produce which they yield with a given quantity of capital and labour. With every step in the progress of population which shall oblige a country to have recourse to land of a worse quality to enable it to raise its food supply rents on all the more fertile land will rise."

Having got thus far, Mr. Rama Rao can follow the rest of my argument with less difficulty if he will keep in mind the assumption which I have made that as a result of the decay of industries and growth of population people have been crowded on to land. When this happens, to quote from Taylor "the number of competing farmers may become so great that the return of the marginal farmers will be depressed far below the necessary minimum but this would result in the elimination of the less efficient farmers and perhaps others as well who would decide they could do better in some other industry." I am inclined to think that this process of elimination has not taken place in India to the extent required and the results of the researches of Dr. Mann and others show that I am not wrong. In the intensive

study which Dr. Mann and his collaborators made of one Deccan village, Pimpla Soudagar, they found that out of a total number of 556 inhabitants only $8\frac{3}{4}\%$ of the families are able to maintain themselves on land alone, 27% on land plus outside labour and the remainder, no less than $64\frac{1}{4}\%$ "appear to be unable at present to reach the standard of maintenance which they themselves set up," i.e., Rs. 3—9—2 per month per head. These facts show how far off the right track Mr. Rama Rao is. The $64\frac{1}{4}\%$ of the families in Pimpla remain in a state of semi-starvation because more remunerative employments are not available or near at hand. I was not discussing the human race as a whole. I was analysing rural conditions in India. The analogy of old countries by which I suppose Mr. Rama Rao means Western countries, does not hold good at all. Industries there did not receive the serious and prolonged set-back India has had to face, nor are surplus populations there shut off from emigration as they are in India. Indeed in most of these countries opportunities for industrial employment and emigration are so great that there is hardly any congestion in rural areas as exists in several parts of India. Under conditions such as these the descent in marginal land is not caused by a rise in prices but by a fall in wages. The well-known law of supply and demand which Mr. Rama Rao has drawn my attention to might have helped him here. The poorer class of Indian ryots are labouring ryots. What they spend on their land is mostly their labour and the yield they get is the return for their labour. When there is not enough demand for labour it goes cheap and it is not a matter for astonishment if a ryot who used to get a return of Rs. 125 for his labour when he cultivated land in the D grade has to rest content with a return of Rs. 100 for the same labour, when compelled by rural congestion to cultivate land of the E grade.

I may now leave readers of the Journal to decide for themselves what reliance should be placed on Mr. Rama Rao's estimate of the importance of the enquiry. Before doing so, however, I should like to point out that I have not suggested anywhere that one should rest content with the results of the enquiry suggested by me. My aim in writing the article was to stimulate thought on rural economics on the part of members of the Union residing in villages and induce them to utilize the excellent opportunities they have for study and observation. I have every hope that members will not fall short of this expectation.

K. Kunhi Kannnn.

SELECTIONS.

Tractor Cultivation at Lyallpur, Punjab.

INTRODUCTION.

The question of cultivation of the land by mechanical means has been largely engaging the attention of agriculturists since the war. Many causes combined are responsible for this. In western countries where most investigation has been done on the subject, it was brought about primarily by the scarcity and high cost of labour. The high prices to which foodstuffs have gone during and since the war also prohibit the maintenance of stock on the same scale as was possible in earlier days.

Up to the present, no literature has been published on the subject of tractors in the Punjab. Indeed very little information is yet available regarding them for any part of India. Enquiries are constantly being made as to what is the best type of tractor to purchase for the Punjab, what is its daily outturn of work, what is the cost of cultivation by this method, etc., etc. It is with a view to answer some of these queries, and to give intending purchasers the benefit of our experience on tractors at Lyallpur up to the present time that this article is published.

TYPES OF TRACTORS.

There are on the market at the present time more than fifty makes of tractors to choose from, and these include at least seven recognized types. They may be classified as follows:—

(1) The ordinary four-wheeled type, whose two rear wheels are driven, *e.g.*, the Austin.

(2) The caterpillar type, which runs not on wheels, but on two endless chain tracks, *e.g.*, the Cletrac.

(3) The three-wheeled type in which all three wheels are driven, two wheels being in front and one behind. It is so arranged that when in motion the weight is equally distributed on all the wheels, *e.g.*, the Glasgow.

(4) The three-wheeled type, with one wheel in front and two behind. In some of these all three wheels are dissimilar in size, and the leading wheel and one of the rear wheels run in the same furrow. Here only the two rear wheels are driven, *e.g.*, the Whiting-Bull.

(5) The three-wheeled type, with two wheels in front and an immense driving wheel, 54 inches wide, in rear, *e.g.*, the Gray.

(6) The self-contained motor plough type, whose engine and gearing are balanced around a driving axle carried in two driving wheels, *e.g.*,

the Crawley. This type can be converted from a plough to work cultivators, harvesting machinery, etc., by removing the rear portion of the frame and substituting for it a footplate arrangement, thereby converting it into a tractor.

(7) The self-contained motor plough type possessing no wheels but driven on an endless track, *e.g.*, the Martin Track. This type is also adaptable to other work and can be converted in much the same way as the last mentioned type.

CHOICE OF TYPE,

Of the seven types enumerated above, the last two are really self-contained ploughs and not tractors though they can be converted into such. So far as is known, no such implements have yet found their way to India. Certain it is that there are none in the Punjab. No further notice will therefore be taken of them in the present article. Types 3, 4 and 5 are also very uncommon, and at present competition lies mainly between the ordinary four-wheeled type and the caterpillar type. It is therefore proposed to confine our remarks to these two main types only.

In selecting a suitable type of tractor it should at the outset be noted that both kinds will not suit all work equally well. Each has its advantages and disadvantages, and the type which will meet the needs of any individual purchaser must be determined to some extent by the various operations for which he intends to use it.

The four-wheeled type may be said to be general purpose tractors, and can perform, amongst others, the following operations :—

- (a) Ploughing, with which most people associate tractors generally.
- (b) Cultivation with disc-harrows, cultivators, spring-tooth harrows, rollers, seed-drills, etc.
- (c) Harvesting operations, with reapers, binders, etc.
- (d) Stationary work, *e.g.*, driving pumps, fodder cutters, threshing mills, ginning machines, cane crushers, etc.
- (e) Haulage work, transporting farm produce, etc.

For all work on the land the driving wheels of these tractors must be fitted with cross-bars or spuds to give them grip and prevent slipping. When the surface travelled on is firm and the spuds can obtain a good hold the percentage of slip is very low, but where the land is loose and sandy in nature a fair proportion of power is lost in slipping. Tractors of this type are, therefore, not specially well suited for after-cultivation work. For haulage work or travelling at other times on *pacca* roads, care must always be taken to remove the spuds. Some tractors are supplied with an outer rim which fits on over the spuds. This saves

much time and labour when travelling from one field to another. The caterpillar type may, if we exclude haulage on *pacca* roads, also be styled a general purpose tractor. As already stated, it possesses no land wheels but as it moves along lays down its own track which consists of two endless chains. As a pulling force on land it far surpasses the wheeled type. The uses to which it can be put include all those enumerated for the wheeled type, but its great merit lies in the fact that it can do as good and as much work on loose sandy soils as it can on those of stiffer types. The endless chain tracks eliminate all the losses connected with slipping. It is on this account by far the most suitable type for after-cultivation work. In addition, the weight of this class of tractor, being distributed over a much larger area, does not pack the soil over which it passes so much as the wheeled type. Experience at Lyallpur showed that, on many occasions where the wheeled tractor failed to pull cultivating implements over loose soil, the caterpillar did the same work with ease.

A point worth notice, especially in land irrigated by canals and wells as in a great part of the Punjab, is the space required for turning, or in other words the size of the headlands. Many of the wheeled types have been observed to require a very large turning area. All of them require a larger area than does the caterpillar tractor. Where fields must necessarily be small the matter of turning radius cannot be neglected. For work in such fields the caterpillar is a much more useful type than the wheeled. It is capable of being turned in its own length, and in actual practice here it is being turned with implement attached on a headland of four yards. It is for this reason suitable in places where the other type is not.

The question of the life of the track of a caterpillar is one on which there is at present very little information. It is evident to even the most casual observer that the wear and tear of the track must be more than that of four wheels, but whilst this is agreed by all there are no statistics available from actual use of these tractors in this country to show exactly what the life of the tracks is expected to be. Though the general feeling is that their life will be comparatively short, there is at present no definite proof that this is so. As to the comparative amounts of fuel consumed in driving these two types when loaded there does not appear to be anything to choose between them.

It may be concluded then that for ploughing on hard firm lands the wheeled type is probably the better and in the long run may prove cheaper, since there are no expensive, and probably short-lived, tracks to be maintained. If, however, the work is to be mainly done on light

sandy soils, or after-cultivation, or in small areas, the caterpillar tractor is the better one to use.

For all kinds of stationary work both types are equally suited, but in this connection a point of practical importance arises. In some tractors, irrespective of which type they fall under, the driving pulley is set transversely in front of the machine. As in most cases the operator sits at the rear, the matter of exact alignment of the belt is of one extreme difficulty and even when got is not easily maintained. Some of the best tractors on the market to-day suffer from this fault. The pulley should be so placed that the driving belt works parallel to the long axis of the tractor. Between engine and pulley a clutch should be interposed, otherwise starting the engine with belt in position is a difficult operation. Many tractors have the driving pulley keyed directly on the crankshaft; this is a great mistake. Most tractors have sufficient horse-power for driving all ordinary farm machines.

Having settled on the type of tractor, the purchaser should take note of the following points if the tractor is to work satisfactorily under Indian conditions. It should be fitted with—

(a) either a tube or honeycomb radiator of at least eight to ten gallons capacity.

(b) a good fan for drawing a rapid current of air through the radiator.

(c) a circulating pump for forcing the water rapidly through the radiator. The thermo-syphon system is much too slow for a hot climate and is useless for stationary work.

In many of the tractors now working in this country the water in the radiator is at boiling point all the time and this within a short time of starting the engine if the load is heavy. This must be detrimental to the life of the engine and, in addition, causes a waste of power which means a higher consumption of fuel per acre. If an ordinary motor car were to heat up to anything like the temperature reached by most tractors the driver would stop and allow it to cool. Because a tractor is not so attractive looking a piece of machinery as a motor car, the idea seems prevalent that overheating is of no importance. This is the reverse of the actual truth. Unlike a motor car, the engine of a tractor is going full speed all the time and so requires even more attention than that of a car. If, therefore, the tractor is to give satisfaction the question of overheating must be looked to.

The carburetter, for preference, should be automatic or fitted with an adjustable jet. This is necessary for economic use with the various grades of kerosine oil.

On account of the extremes of temperature in the Punjab pre-heated air with hot-spot (as in the Austin) is considered essential for engines intended to run on kerosine oil. This will economize fuel and result in cleaner running of the engine with less trouble from carbonized sparking plugs.

Under Indian conditions a tractor is working most of the time in an atmosphere saturated with dust and grit. If this grit is allowed to enter the cylinders with the air, it gets into the valve seatings causing them to leak and also causes wear to the pistons and cylinders much the same as would emery. To overcome this a water air clarifier should be fitted. A case recently came to the notice of the writers where pistons had to be replaced after three months' use due to excessive wear caused by improper filtration of air.

Great difficulty is often experienced in starting the engine. This could be surmounted if impulse starters were fitted. There would also be less danger of backfiring and damage to the operator.

Correct lubrication is a vital matter in maintaining the tractor in the best working condition and in keeping down the account for replacement of parts. It should be automatic for all the main working parts and should be rendered as foolproof as possible. Forced lubrication by means of a pump is best and a pressure gauge should be fitted whereby the operator can see at any time whether the machinery is being properly oiled. Grease caps should be provided on all other movable parts and should be of sufficient capacity to maintain the bearings efficiently lubricated for one day. Experience shows that oil holes quickly get filled with grit and the average operator in this country will not take the trouble to clean them out.

LIFE OF A TRACTOR.

Most authorities limit the span of life of a tractor to five years, but at present there is no evidence that it will not be more. In most makes of tractor the engine runs at a speed of about 1,000 revolutions per minute. If this speed could be halved, while still maintaining, say, 25 B.H.P., it would probably be possible to prolong the life of the engine by at least 50 per cent as it is always this part which wears out first. Lowering the speed of the engine might mean an increase in the weight of the tractor, but in a dry climate like India this would make little difference. It might also increase the price but this would be more than compensated if the tractor were to last, say, seven-and-a-half years instead of five. The original capital outlay is not so important as prolonging its life and keeping down cost of replacements by fitting out the tractor to suit the climate in which it is intended to work.

The question of spare parts is at present one of the most serious drawbacks to the extension of work by tractors in India. There are many makes on the market here but only a few of the agents can give a written guarantee that all possible renewals are stocked in the country. Until this is possible no one can with any confidence recommend the farmer to discard the bullock for the motor driven plough. As an instance, a case may be cited where in the Punjab some radiator tubes of a well-known make of tractor became accidentally damaged. No replacements could be had in India and six months elapsed before they arrived from England. During all this time the tractor was useless, and had the owners been solely dependent on it for cultivation the result would have been nothing short of disastrous. The position with regard to spare parts in India is improving but there is still much to be done before it is even satisfactory. At present it cannot be said to be so. It is only to be expected that, with such a high speed machine as a tractor, breakages will occur. The impossibility of obtaining a full supply of spares puts the use of certain tractors beyond consideration. It is not going too far to say that before deciding on purchasing any particular tractor the buyer should obtain a written certificate that all spare parts of this machine can be had in India.

The next serious handicap to the use of tractors in India is the lack of properly trained mechanics to look after them. When a firm sells a tractor, a man is usually sent for a few days to instruct the purchaser in its use. With only the help given during these few days no man without previous experience, is capable of taking proper care of the tractor thereafter. None but a man who thoroughly understands all about motor engines and their care is of any use if the tractor is to be maintained in proper running order. It is thus hopeless for any one to attempt to run a tractor until he puts it in charge of a properly trained mechanic. These are difficult to obtain in the East. Untrained men do not understand the use of mechanical tools and one invariably finds them tackling the sparking plugs with hammer and chisel. A half-trained mechanic is an unsound investment where tractors are concerned, for through ignorance or neglect he can cause the breakage or wear of some part which will cost much to replace. For the economic use of fuel, as well as to keep down the replacements bill, a sound mechanic is indispensable.

If motor tractors are to be a success here, it is felt that the selling firms should have a staff of highly trained mechanics, one of whom it would be possible for the purchaser to engage for a period of, say, three to six months during which time he would train another mechanic in all

that he could reasonably be expected to know. Efficient *mistries* are not to be picked up at every corner in India, and if every purchaser could have his own man trained by some such scheme as that suggested, it is believed that the popularity of tractors would be greatly increased.

Another difficulty with which the purchaser of a tractor is met is that the instructions sent with the machine are not sufficient. Some firms issue with their tractors a manual of instructions, others either issue none or supply a handbook with so little information that it is of little use. What is wanted with every machine coming into India is a manual after the style of that provided with the Ford motor car.

It is difficult to give an exact figure as to the size of an economic holding for a tractor. This will depend on the system of cultivation, the number of operations it is proposed to perform with the tractor, etc. Experience has shown here that five acres per day is the maximum average that can be worked with a three-furrow plough, while 12-15 acres can be disc-harrowed. Allowing for the tractor being out of commission from all causes for eight days in the month, it means that in a month 110 acres could be ploughed, while two months' preparation for *rabi* and two for *kharif* crops would allow for a total of 300 acres per annum. These figures depend largely on the system of cultivation and are here taken for 100 per cent intensity.

The economic use of a tractor depends upon how many operations are to be done by it. The depreciation generally allowed is at the rate of 20 per cent per annum, and it depreciates whether in constant use or part time idle. To be economical, therefore, it should be used for all kinds of general work, in addition to the cultivation of the ground. Many operations are carried out in the farmyard which could more economically and more speedily be done by tractor power. These include fodder cutting, cane thrashing, threshing, etc. The owner of a tractor should, therefore, if he is to get full value out of his purchase, provide himself with suitable machinery to be driven by it.

The following are the main points to attend to in the purchasing of a tractor :—

(1) It should be suited to the kind of work for which it is to be used. This work will determine which type should be purchased.

(2) It should be provided with a large radiator, a fan and a force pump for cooling.

(3) It should have a proper kerosine oil vaporizer.

(4) It should have a water air filter.

(5) An impulse starter is a great advantage.

(6) Lubrication should be automatic for all the main working parts.

(7) All possible working parts should be encased and not exposed to wear and tear from dust and grit.

(8) There should be a complete supply of spare parts in India.

(9) The selling firm should be asked to supply a skilled mechanic for a period of from three to six months.

(10) A complete manual of instructions is necessary with diagrams of all working parts and a complete spare list.

(11) It should have two forward speeds of about $2\frac{1}{2}$ and 4 miles per hour respectively and one reverse speed.

(12) The draw-bar should have a wide range of lateral adjustment to enable tractor to run on unploughed land.

(13) Belt pulley should be parallel to long axis of tractor with sufficient clearance for at least an 18" diameter and 6" wide pulley capable of working belt either forward or backward.

(14) A clutch should be interposed between engine and belt pulley to facilitate starting.

(15) Engine should be governor controlled.

COST OF CULTIVATION.

The following are the costs of the various operations at Lyallpur as shown by the work done up to the present. The soil is light alluvial.

(a) *Ploughing*.—Caterpillar type working with a three-furrow, self-lift plough.

Average depth ploughed	..	..	6 inches.
„ width of each furrow	..	..	12 inches.
„ work done	..	..	0.82 acre per hour.
„ area ploughed	..	..	5.0 acres per day.
Fuel used	..	..	2.2 gal. per acre.
Lubricating oil	..	..	0.2 gal. per acre.

COST PER ACRE.

				Rs.	A.	P.
Labour	..	..	..	..	0	10 0
Fuel	..	..	..	..	2	15 0
Lubricating oil and grease	..	..	..	..	1	0 0
Depreciation and interest on capital	..	..	..	..	0	15 0
Total	..	..	..	..	5	8 0

(b) *Ploughing*.—Caterpillar type working with a two-furrow, self-lift plough.

Average depth ploughed	..	..	6 inches.
„ width of each furrow	..	..	12 inches.
„ work done	..	..	0.53 acre per hour.
„ area ploughed	..	..	3.3 acres per day.
Fuel used	..	..	2.9 gal. per acre.
Lubricating oil	..	..	0.36 gal. per acre.

COST PER ACRE.

					Rs.	A.	P.
Labour	..	..	..	..	..	1	0 0
Fuel	..	..	..	..	..	3	8 0
Lubricating oil and grease	..	..	..	..	..	1	14 0
Depreciation and interest on capital	..	..	..	..	..	1	7 0
Total	..	..	..	..	..	7	13 0

(c) *Disc-harrowing*, with caterpillar type.

Average depth	..	..	4 inches.
„ width	..	..	9 feet.
„ work done	..	..	2.6 acres per hour.
Average work done per day	..	..	12 acres.
Fuel used	..	..	0.96 gal. per acre.
Lubricating oil	..	..	0.1 gal. per acre.

COST PER ACRE.

					Rs.	A.	P.
Labour	..	..	..	..	..	0	4 0
Fuel	..	..	..	..	..	1	1 0
Lubricating oil and grease	..	..	..	..	..	0	3 0
Depreciation and interest on capital	..	..	..	..	..	0	6 0
Total	..	..	..	..	..	1	14 0

Cultivation is also being done with a cultivator which covers a width of 7½ feet each time, and with four spring tooth harrows fastened rigidly together. These take in a width of 11 feet. Figures are not yet available to show the costs of these operations.

The method adopted for arriving at the depreciation and interest on capital requires explanation.

Depreciation @ 20 per cent	..	..	Rs. 1,040 per annum.
Interest on capital @ 5 per cent	..	..	260 „

Total .. Rs. 1,300

Average daily depreciation Rs. 3-9-6

Allowing for tractor being out of commission from all causes 25 per cent of the time, the average depreciation per day worked is therefore Rs. 4-12-0. The average day's work with a three-furrow plough being 5 acres, this amounts to As. 15 per acre. With a two-furrow plough it is, on the basis of 3.3 acres per day, Rs. 1-7-0 per acre, and with a disc-harrow, at 12 acres per day, As. 6 per acre.

(d) *Ploughing* with wheeled type, using three-furrow, self-lift plough.

Average depth ploughed	5½ inches.
„ width of each furrow	12 inches.
„ work done	0.79 acre per hour.
Fuel used	2.45 gal. per acre.
Lubricating oil	0.15 gal. per acre.

COST PER ACRE.

	Rs.	A.	P.
Labour	0	12	0
Fuel	2	12	0
Lubricants and grease	0	6	0
Depreciation and interest on capital	1	4	0
Total	5	2	0

Depreciation and interest on capital is arrived at in a way similar to that done with the caterpillar type and in this case is as follows:—

Depreciation @ 20 per cent ..	Rs. 1,370	per annum.
Interest @ 5 per cent	342	„
Total ..	Rs. 1,712	

Average daily depreciation and interest, Rs. 4-11-0. Depreciation per day worked, allowing for tractor being 25 per cent of time out of commission, Rs. 6-4-0 or Rs. 1-4-0 per acre.

The costs do not include anything under the heading “replacements and spare parts,” as up to the present there is no information on which to base such an allowance. The amount shown for fuel in each case includes both petrol and kerosine. When starting the tractors it is always necessary to use petrol for a short time till the engine becomes heated, after which kerosine is used.

It was found that the wheeled type of tractor used could not pull the three-furrow in the class of soil under experiment if the depth exceeded 5½". When it was desired to plough to a greater depth it was necessary either to use a two-furrow plough with it or use the three-furrow with the caterpillar type. Finally, mainly owing to slipping the wheeled

type was unable to pull the disc-harrow, during after-cultivation, at the depth which was required. All this work had therefore to be done with the caterpillar.

TRACTOR TILLAGE IMPLEMENTS.

(a) *Ploughs*.—There are two types of ploughs in use with tractors :—

1. The mould-board.
2. The disc.

The former is the older and more common and is simply an enlarged form of the English share and Indian Rajah ploughs. Instead, however, of having but a single share, two, three or four are fitted together by means of a framework mounted on wheels and pulled as a unit. The number of shares being thus so variable the prospective buyer very naturally enquires how many his plough should have. The number depends primarily on the draw-bar B.H.P. of the tractor, which in most cases is 8 to 12 and is quite sufficient for a three-furrow plough on most Punjab soils. Experience has so far shown at Lyallpur that it is waste of time and power to use either the caterpillar or the wheeled type with a two-furrow plough. Both tractors are able here to pull a three-furrow as quickly as a two-furrow plough. Where, however, it was desired to plough more than $5\frac{1}{2}$ " deep at Lyallpur it was found that the wheeled type could only pull a two-furrow plough.

With regard to the choice between mould-board and disc ploughs, the former is better suited to varying conditions of soil and was found at Lyallpur to disturb the level of the land much less than the latter. This question of level is one of great importance on irrigated lands. Experience here makes us therefore favour the mould-board rather than the disc.

There are many makes of mould-board ploughs on the market with little to choose between them. Some have distinct advantages over others and those with the following points should be chosen for preference :—

(a) The third share in the case of a three-furrow plough should be removable, so that in the case of stiff land or deep-ploughing, where the tractor cannot pull three-furrows, the implement may be convertible into a two-furrow plough. Many makes provide for this.

(b) The tips of the shares should be adjustable, i.e., it should be possible to increase or decrease the angle of dip at will. It is invariably found at Lyallpur that after a short time in work the point wears wedge-shaped from below, tending to make the plough run shallow especially in hard soils. In those ploughs whose tips are not adjustable new tips or resharpening of the old ones will often be required.

(c) Adjustments for altering the width of furrows, as well as the depth, should be provided.

(d) The plough should be automatically self-lift. Some of the ploughs at present on the market require a man to sit on them, steer them and raise and lower them at the headlands. This is quite unnecessary and adds to the labour bill. In some of the more improved ploughs the control is done by the tractor operator simply by pulling a lever or a rope which passes forward to his position on the tractor. This is all that is required, and on the Lyallpur farm this type of plough has given great satisfaction.

In the disc-plough instead of shares we have got two, three or four saucer-shaped discs about 24" in diameter. These are set at an angle of 120° to the line of draught, the concave side facing forward. On being drawn through the soil the discs revolve cutting out a furrow in much the same manner as a share, but unlike the furrow cut by a share the disc-cut furrow is broken up and set upright rather than inverted. It disturbs the level of the land more than the mould-board plough and on this account is not so useful on artificially irrigated lands. The ground from which the furrow has been cut is in the shape of the segment of the arc of a circle. Consequently where successive furrows adjoin, a ridge is left and the ground is not all ploughed to an even depth. For breaking up rough land containing sugarcane stumps the disc plough was found very useful. On hard soils it is necessary to load the plough with additional weights to keep it in the ground.

A plough fitted with a self-lifting apparatus is very strongly recommended, even though manual labour may be plentiful and cheap. It is a great timesaver as the tractor need never stop at entering or emerging from the furrow. The operation of lowering or raising the shares simply consists in operating a lever from the tractor, whose driver works both tractor and plough. In non-self-lift ploughs three operations are usually necessary, *viz.*, two levers to be manipulated for raising and lowering the shares and one lever for steering. This is too much for any one man to do sufficiently quickly and is in addition a work requiring a fair strength. Consequently the tractor must come to a stop till the necessary operations are performed. In a day's work all these halts amount to a considerable loss of time.

Many ploughs are fitted with steel rope hitches. With these it is almost impossible to guide the plough into the furrow or to control it on the headlands. The plough is inclined to float around the headlands, crashing into the rear of the tractor should the latter come suddenly to a halt. Triangular draw-bar hitches providing for lateral adjustments are best.

(b) *Cultivators*.—This implement has from ten to twenty tines usually arranged in two rows. The cultivator in use at Lyallpur has eleven tines, five in front and six in rear, and covers a width of $7\frac{1}{2}$ feet. The depth is adjustable.

This is considered quite large enough for any ordinary tractor. The work done somewhat resembles in quality that of a *desi hal*. It is an economical implement for stirring up soils on fallow lands. On certain rain-fed areas with sandy soil where nothing but grams can be grown, the cultivator has been doing good work and has replaced ploughing.

(c) *Disc-harrows*.—These implements are of two types, some having only one row of discs, some having two rows. The latter is the tandem type and is much more efficient than the former. Each row of discs is broken in the middle and the halves hinged together. The inclination of the two halves to each other is thus adjustable. For good work this angle must be fairly small. In a one-rowed implement this is inclined to disturb the level of the ground a good deal and the second row is necessary, especially on irrigated lands, to counteract the disturbing influence of the first. In addition, it does more thorough work. These implements have a provision for carrying weights if they do not penetrate sufficiently into the ground when unloaded. The tandem disc-harrow is the most efficient pulverising implement so far tried at Lyallpur.

(d) *Spring tooth harrows*.—An effort has been made to utilize the bullock-drawn spring tooth harrows for tractor cultivation by rigidly fixing together four of these implements. The experiment was a decided success. The power required to draw them was small, and a width of 11 feet was cultivated each time. A large *sohaga* (wooden leveller) was also fitted on in the rear and in one operation the ground was ready for sowing.

Much investigation lies ahead in the matter of suitable tillage implements for this country. It is thought that probably heavy western implements of the types now being imported are not essential for the soils of the Punjab and that just as good results might be obtained with implements lighter in nature and possibly less thorough in their work. The zemindar has for centuries been getting abundant harvest whilst doing little more than scratching the surface of the ground with his *desi hal*. The question therefore remains to be solved, whether a type of implement doing lighter work than the heavy tractor plough of to-day might not be evolved, reducing the cost of cultivation whilst in no way decreasing the present time outturns.—*The Agricultural Journal of India*, Vol. XVIII, Part I.

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Cultivating the Soil.

The various implements used for the cultivation of the soil serve three main purposes. They release plant food, kill weeds, and make a mulch on the surface of the soil so as to prevent the loss of water stored up for the use of the crops. All kinds of crops respond to cultivation, but some crops, such as hay and pastures, cannot be cultivated very well because the ground is so thickly covered with plants. Nevertheless, even old pastures are sometimes disked over, or harrowed, so as to tear apart some of the plants and stimulate the growth of more newer ones. Cultivation might be taken to mean all operations by which the soil is stirred, and this would include plowing, disking, rolling, harrowing, as well as the actual use of a cultivator. All of this, however, comes more properly under the head of soil tillage. When we speak of cultivation in its narrower sense we usually mean the stirring of the soil between growing plants in the field. Thus, we cultivate the corn field, or the garden, or the orchard. For the purpose of cultivating a crop that is already growing, it is often not advisable to cultivate very deeply; thus in the case of corn we cultivate fairly deeply at first while the plant is young, but after the corn plant gets older the roots are fairly close to the top of the soil, and if the cultivator were to be run as deeply as at first, it would injure the corn plant. Therefore, farmers who grow corn successfully cultivate just deep enough toward the last so as to keep the soil stirred up and prevent the growth of weeds.

Cultivation releases plant food from the soil, as has been stated already. This does not mean that cultivating the corn field puts more plant food in the soil; what it does do is to break the ground up into small particles so that the sun and the air and the moisture can get well down into it, and thus help along the chemical changes which are necessary to liberate the essential plant food constituents. The most important of these are nitrogen, phosphoric acid and potash. The potash and phosphoric acid in particular are present in most soils in very large quantities, but they are not "available"; that is to say, they are tied up in such chemical form that the roots of the plant cannot make use of them. When the soil is cultivated however, the warm air and the sunshine and the moisture act upon the compounds which hold these valuable fertilizing elements tied up, and liberate them so that the roots of the plant can use them. This is what is meant when it is said that cultivation releases plant food.

Of course, everyone knows how cultivation kills weeds. There are scores of different kinds of weeds that grow up in almost every field,

and unless they were kept down the crop which the farmer is trying to grow might be smothered out. The good farmer, therefore, tries to keep ahead of the weeds, and this can best be done by keeping the soil so loose that the weeds cannot get a chance to start. Every seed must have a chance to lie quietly in the soil with some moisture and heat around it for a few days before it can grow. Naturally, then, if the soil is stirred often enough the weed seeds are prevented from sending up young plants, or, if the young plants do start they are disturbed and killed before they have taken a good hold on the soil. Keeping down the weeds is a very important part of cultivation, and especially in crops like corn, potatoes, beans, and other hoed crops, which must make a rapid growth unhindered by weeds and with plenty of available plant food, if a good crop is to be secured.

The third reason why cultivation is so essential is because it helps to hold water in the soil. All, or practically all, of the plant food is taken from the soil in solution; that is, the plant food must be dissolved in water before the roots can take it up.

Sometimes we do not think of these things when we see farmers cultivating a corn field during the hot weather of the summer holidays. Sometimes, perhaps, we are driving the cultivator ourselves, and think it does not matter if we skip a little bit here or there. But when we realize just how important cultivation is and how much it means to the plant, we can readily understand that we should do the job as well as we can.—*The Farmer's Advocate*.

ANNOUNCEMENT.

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Further information may be obtained from W. Davison, Esq., B.S.A., Live-Stock Expert in charge of Amrit Mahal Department, Bangalore.

W. DAVISON,
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